Lehigh

University Catalog
Courses for 1987-88

March, 1987

Subject Areas

The university offers the following undergraduate major programs. While most of these programs are offered as majors within a specific academic department, in some cases subjects transcend departmental lines or are emphases within a major program. Minors are available in virtually all major programs. Programs that are offered only as minors are described under the entries for individual colleges in Section III, Academic Programs in the Colleges, and under individual departments in Section V, Descriptions of Courses. Graduate programs are offered in many of the subjects listed. These are described in Section IV, Graduate Study and Research.

Accounting
American Studies
Applied Science
Architecture
Art
Arts/Engineering
Biochemistry
Biology
Chemical Engineering
Chemistry
Civil Engineering
Civil Engineering/Geological Sciences
Classical Civilization
Classics
Computer Engineering
Computer Science
Economics
Electrical Engineering
Electrical Engineering/Engineering Physics
Engineering/Master of Business Administration
English
Environmental Sciences and Resource Management
Finance
Foreign Careers
French
Fundamental Sciences
Geological Sciences
Geophysics
German
Government
History
Industrial Engineering
International Relations
Journalism
Journalism/Science Writing
Management
Marketing
Materials Science and Engineering
Mathematics
Mechanical Engineering
Engineering Mechanics
Molecular Biology
Music
Natural Science
Philosophy
Physics
Engineering Physics
Predental Science
Premedical Science
Psychology
Religion Studies
Social Relations
Spanish
Statistics
Theater
Urban Studies

Lehigh

Contents

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Lehigh (USPS 309-508) is published by Lehigh University four times per annum, in January, March, April, and August. Second-class postage paid at Bethlehem, Pennsylvania 18015 U.S.A.

Every effort has been made to insure accurate, consistent and complete information in this edition. However, the editors recognize their fallibility and refer the reader to a boast made by the editors of the 1771 edition of *Encyclopaedia Britannica*: "With regard to errors in general, either falling under the denomination of mental, typographical, or accidental, we are conscious of being able to point out a greater number than any critic whatever."

Admission (215) 758-3100
College of Arts and Science (215) 758-3300
College of Business and Economics (215) 758-3400
College of Education (215) 758-3225
College of Engineering and Applied Science (215) 758-4025
Graduate School (215) 758-4280

The photographs in this edition of LEHIGH were taken from a scrapbook compiled by Frank Ware Jefferson, who earned a bachelor's degree in mechanical engineering from Lehigh in 1906. The photos show the university and the city of Bethlehem around the turn of the century. Most were taken by William M. Flickinger, a Bethlehem commercial photographer. Several were taken by Jefferson, and one was taken by Gustave A. Conradi, who had a photo-supply shop in Bethlehem.

Jefferson wrote notes under some of the photos to describe their significance to him. The inscription beneath a train engine, for example, says, "Reading loco. that pulled us to Phila. 1905."

Other pictures show Packer Memorial Church, Packer Hall (now also called the University Center), Williams Hall (built in 1903), and the covered bridge over the Lehigh River. The narrow wooden bridge was replaced in the 1920s by a wider, steel structure that is now part of Route 378, and is known as the Hill-to-Hill Bridge.

Jefferson himself appears in a photo of Lehigh's 1905 summer school class. And many of his professors appear in a photo of Lehigh's forty-four faculty members of 1905-06.

After graduating from Lehigh, Jefferson worked until his retirement for Struthers Wells Corp., which manufactures steam generators and processing equipment in Warren County, Pa. He returned regularly to Lehigh, and expanded his scrapbook with pictures of his class reunions, his classmates, and the Lehigh and Moravian College campuses.

Jefferson died in 1963 at the age of 80. His scrapbook was found in an office in Linderman Library several years ago. Besides the photos, the album contained a remnant of his brown graduation gown and a record that his mother kept of his expenses during his freshman year, which totaled $491.71.

—Kurt Pfitzer

"Central N.J. R.R. bridge & covered bridge near station. 1905 G.A. Conradi." The covered Hill-to-Hill Bridge over the Lehigh River, just north of campus, has been torn down and replaced.

I.

Information of General Interest

This section includes information related to admission, accreditation, advanced placement, transfer students, tuition and fees, financial aid, academic regulations, campus life, and student services. Similar information for graduate students may be found in Section IV. The university history, minibiographies of its presidents, listings of buildings, and maps are found in Section VI.

Accreditation

Lehigh University is accredited by the Middle States Association of Colleges and Schools.

The undergraduate and master's programs in business administration are accredited by the American Assembly of Collegiate Schools of Business. In 1985, the assembly gave the college continuing accreditation for ten years in these programs, and also granted initial accreditation of the college's undergraduate program in accounting. Lehigh is among approximately fifty schools among the 1,200 offering business degrees that received accreditation for both accounting and business administration programs. The engineering curricula are accredited by the Accreditation Board for Engineering and Technology. Various College of Education programs are accredited by the National Council for Accreditation of Teacher Education, including Commonwealth of Pennsylvania approval for certification programs. Programs in chemistry are approved by the American Chemical Society.

Policy of Equality

It is the policy of Lehigh University to provide equal opportunity on the basis of merit and without discrimination because of race, color, religion, sex, age, national origin, citizenship status, handicap, or veteran status.

Admission Guidelines

The enrollment of Lehigh University is regulated by action of the board of trustees, with a resulting limitation in the number of candidates who can be admitted each year to the several divisions of the university.

In the selective procedure necessitated by limitation on enrollment, the university, through its office of admission, takes into account a number of criteria that are believed to have some individual validity and in combination a high degree of validity in predicting success in college work.

The material that follows pertains to undergraduates. Graduate students should consult Admission to Graduate Standing, Section IV.

The admission policy of the university is designed to encourage students with varied backgrounds to consider study at Lehigh. The courses or units required for admission represent the quantitative equivalent of the usual four-year college preparatory program and include certain prescribed subjects for candidates depending upon their college and curriculum choice.

An applicant's full potential as a Lehigh student, including evidence of academic growth and the desire to learn, are special qualities that may not be reflected in mere accumulation of units. Such qualities are considered when appraising applicants.

All applicants should have completed four years of English, two to four years of history and social studies, three or four years of mathematics, and two to four years of laboratory science. Chemistry is required and physics is recommended for candidates planning studies in science or engineering.

Students planning to enter the College of Engineering and Applied Science or the College of Business and Economics, or the bachelor of science program in the College of Arts and Science, must have studied mathematics through trigonometry.

Students planning a bachelor of arts degree in the College of Arts and Science present credit upon entrance for at least two years of study of one foreign language. Further foreign language study is strongly encouraged.

One of the attractive features of the university is the ease with which a student may normally transfer from one curriculum or college to another. A student must, however, be enrolled in an undergraduate college for two semesters and be in good standing, before transferring to another college. Such transferring may necessitate a student's obtaining additional background for the new discipline on campus or elsewhere.

Minimum subject matter requirements (16 units)
English 4
foreign languages* 2
college preparatory mathematics** 4
electives 6

*Only in exceptional cases and for otherwise well-qualified candidates will waivers of the requirement in foreign languages be granted for admission to any one of the three undergraduate colleges.

**Waivers of the requirement in mathematics are granted to otherwise well-qualified candidates for admission who propose to major in one of the following fields offered by the College of Arts and Science: American studies, art, classics, theater, English, modern foreign languages, government, history, international relations, journalism, music, philosophy, religion studies, social relations, and urban studies.

Note: Electives should include such college preparatory subjects as languages, social studies, and sciences.

The quality of the candidate's work is more important than merely meeting minimum subject matter requirements.

The strength of preparation is judged primarily by rank or relative grade in class; by the extent to which grades are distinctly higher than the average grade; by evidence of improvement or deterioration in quality of record as the secondary school career progressed; by relative success in the subjects the student proposes to continue in college; by the degree of difficulty of courses—particularly in the senior year; and by the comments and recommendations of the principal or headmaster.

Entrance Examinations

All candidates for admission to the freshman class are required to write entrance tests prepared and administered by the College Board. It is the responsibility of the student, not the school attended, to request the College Board to report official scores to Lehigh.

Scholastic Aptitude Test. Each candidate is required to write the Scholastic Aptitude Test (SAT) to provide the university with a measure, on a national scale, of aptitude and readiness for college study. The university prefers that this test be written early in the senior year. Many students write the SAT in the junior year and ask the College Board to report the results to Lehigh. In some cases it is not necessary for students to repeat this test in the senior year.

Achievement Tests. Each candidate is required to write three College Board Achievement Tests. One of these must be an English test.

Candidates for a science program in the College of Arts and Science or for a program in the College of Engineering and Applied Science are expected to write a Mathematics (Level I or Level II) Achievement Test. Candidates for the College of Engineering and Applied Sciences are expected to write a Science (chemistry or physics) Achievement Test.

Candidates for a bachelor of arts degree from the College of Arts and Science, including five-year Arts-Engineering candidates, should write an Achievement Test (or Advanced Placement Examination) in any foreign language to be studied in college. Other candidates write tests that they may choose in consultation with their advisers. The English test and two additional Achievement Tests should be written in the senior year, unless satisfactory junior-year scores were submitted to Lehigh University.

Test information and applications may be secured from schools or the College Board at either of the following addresses (whichever is closer to the candidate's home or school): P.O. Box 592, Princeton, N.J. 08541, or 1947 Center St., Berkeley, Calif. 94704. Candidates writing tests outside the United States should direct their correspondence to the Princeton address.

Candidates should register for the tests early in the senior year and not later than one month prior to the test date (two months for candidates who will be tested in Europe, Asia, Africa, Central and South America, and Australia).

The candidate is responsible for requesting that the test scores be sent to Lehigh University—either by indicating Lehigh on the College Board application or, having failed to do this, by request to the College Board office.

Recommendations

The office of admission secures directly from counselors, principals, or headmasters information about candidates' other qualifications. Such information relates to the candidates' health, emotional stability, intellectual motivation, social adjustment, participation in school activities, and established habits of industry and dependability.

Interviews

Prospective freshmen and their families are highly encouraged to visit Lehigh, so that they may tour the campus and talk with an admission officer. Appointments should be made. Often it is possible to speak with faculty members and students during the visit.

The office of admission is open for interviews on weekdays from 9 to 11 A.M. and from 1:30 to 4 P.M. Tours are conducted on weekday afternoons while classes are in session. The office of admission also holds interviews on some Saturday mornings during the fall. Interviews are not held from mid-February until April 1, while applications are being reviewed..

Although a personal interview is not required of all candidates, the university reserves the right to require an

interview whenever this appears desirable, and to base determination of admission in part on the report of the interviewer.

How to Apply

Students may secure applications by writing to the Office of Admission, Alumni Memorial Building 27, Lehigh University, Bethlehem, Pa. 18015, or by telephoning (215) 758-3100. Students may also use the Common Application available from counselors in secondary schools. Applications should be filed no later than March 1. Preference is given to those received by January 1.

Application fee. Each undergraduate application for admission must be accompanied by an application fee. The fee is nonrefundable, whether or not the candidate matriculates at Lehigh University. It does not apply toward tuition.

Early decision. The university will give candidates an early favorable decision on their applications if they meet the following criteria: 1. the person is certain that Lehigh is the first choice of college; 2. preliminary credentials, including Scholastic Aptitude Test scores, show clear qualification for admission.

On this basis the committee on admission selects candidates who have submitted requests for early decision by November 1. The decision will be made by December 1. If the decision is favorable, it is assumed the candidate's academic strengths will continue throughout the senior year of high school and that all admission requirements (including College Board Tests) will be completed. On receiving a favorable decision, the candidate promptly withdraws other applications and does not apply elsewhere.

Early-decision candidates whose parents have submitted the Financial Aid Form receive notice by December 15 of the action taken on requests for financial aid.

The early-decision plan is not appropriate for all candidates. There are many candidates who are unable to make an early college choice, and they are not penalized. Candidates who do not receive favorable replies to their requests for an early decision should not feel discouraged. Only a portion of the class is selected under this plan. The committee on admission prefers to take action on most applications later in the academic year.

Admission and Deposit

Selection of candidates for the freshman class entering in August is made between mid-February and April 1 following receipt of College Board scores and preliminary secondary school records. The university subscribes to the Candidates' Reply Date, which has been set at May 1.

When preliminary credentials are complete and the person has been offered formal admission, the university will request that the student notify the director of admission of acceptance of the offer. A deposit is also requested by Lehigh at this time to hold the place for the student in the limited enrollment. This deposit is not an additional fee but is applied toward tuition and room and board charges for the first semester. However, the deposit is forfeited in case of failure to enroll for the specified semester.

Advanced Placement

The university offers capable students who have superior preparation an opportunity for advanced placement and/or college credit. Many secondary schools, in association with the College Board, offer college-level work. Students participating in these courses should write the Advanced Placement Tests offered by the College Board.

Students who achieve advanced placement are afforded three major advantages. First, they commence study at Lehigh at a level where they will be academically comfortable. Second, students who qualify for college credits may be graduated at an earlier time—with resulting savings in time and tuition outlay. Third, qualified students may, in the Lehigh senior year, enroll for a limited amount of work for graduate credit.

Entering freshmen who ask the College Board to send their advanced placement grades to Lehigh are considered for advanced placement. Examination grades range from a low of 1 to a high of 5.

Some departments noted below offer examinations during Freshman Orientation to students who studied college-level subjects in secondary school but did not write the advanced placement tests. Entering freshmen wishing to write an examination in any Lehigh course should notify the office of admission in writing prior to August 1. The student should specify the number and title of the course. Students who receive credit on the basis of advanced placement grades need not write Lehigh tests to confirm the credit granted.

Current practice at Lehigh is as follows:

Art and architecture. Three credit hours are given to those students who earn grades of 4 or 5 on the advanced placement history of art examination. Those students who earn grades of 4 or 5 on the advanced placement studio art examination also receive three credit hours.

Biology. Three credit hours for Biol 21 are given to those who earn grades of 4 or 5.

Chemistry. Eight credit hours for Chem 21, Chem 22, and Chem 31 are granted to students who earn a grade of 5. Those students who earn a grade of 4, or who score 750 or higher on the chemistry achievement test, are granted five credit hours for Chem 21 and Chem 22 and may apply to the department for a special examination that, if completed successfully, will result in an additional three credit hours for Chem 31.

Computer Science. Students receive three semester credit hours for CSc 11 for a grade of 3. Those students who earn grades of 4 or 5 receive four credit hours for CSc 17 only.

English. Advanced placement and six credit hours are given for freshman English to students who earn a grade of 5. These students need not take the regular freshman English courses, but they are encouraged to elect Engl 11 and 12, seminars designed to give advanced freshmen practice in reading and writing at the college level. Students who receive a grade of 4 or who have a score of 700 or higher on the verbal section of the Scholastic Aptitude Test or the English Composition Achievement Test receive three hours of credit in freshman English; these students complete the six-hour requirement by taking an English course suggested by the department. Students whose verbal scores are between 650 and 690 and who have received a grade of 3 on the advanced placement test may apply to the department for a special examination that, if completed successfully, will result in three hours of credit and exemption from Engl 1.

Government and Politics. Three semester credit hours for Government I are given to students who earn grades of 4 or 5.

History. Students who receive a grade of 3 on the American History or European History Test receive advanced placement but not credit. Those who earn grades of 4 or 5 on the American History Test receive six semester hours of credit; those who earn grades of 4 or 5 on the European History Test receive three semester hours of credit. A special course, Hist 51, is available to qualified students.

Latin. Students receive three semester hours of credit for a grade of 4 or 5 in the Vergil examination; those who successfully write examinations in more than one area (e.g. Vergil and lyric poetry) receive six hours of credit.

Mathematics. Four semester hours of credit for Math 21, Analytic Geometry and Calculus I, are granted to those who earn grades of 3 or higher on the Calculus AB examination. To those who earn grades of 3 or higher on the Calculus BC examination, eight hours of credit are granted for Math 21 and Math 22, Analytic Geometry and Calculus I and II.

Modern foreign languages. (French, German, Hebrew, Russian, Spanish). Students receive three semester hours of credit for grades of 4, and six hours of credit for grades of 5 on the advanced placement tests. Those who write the achievement tests and score 750 to 800 receive three hours of credit.

Music. Three semester hours of credit are given to those students who earn grades of 3 or higher on the advanced placement music theory examination.

Physics. Four hours of credit are given for Physics 11, Introductory Physics I, for a grade of 5 on the Physics B examination or a grade of 4 on the mechanics section of the

Physics C examination. If a student receives credit for Physics 11, four hours of credit will be given for Physics 21, Introductory Physics II, for a grade of 4 on the electricity and magnetism section of the Physics C examination. If a student wishes to be considered for credit for Physics 12 or 22, Introductory Physics Laboratory I and II, he or she should see the chairperson of the physics department with evidence of laboratory experience. A test is offered during freshman orientation.

International Baccalaureate. Students who earn the international baccalaureate are granted credit in higher-level subjects in which they earn scores of 5 or higher.

Transfer Students

Each January and August, students who have attended other colleges and universities are admitted with advanced standing. Candidates for transfer admission must meet the high school subject matter requirements prescribed for entering freshmen. Entrance examinations are not required. The quality of the college record and the number of spaces available in the program the student wishes to study are the major considerations of the committee on admission in reviewing transfer applications.

A candidate who has been dropped from another college for disciplinary reasons or for poor scholarship or who is not in good standing at another college is not eligible for admission.

A candidate who has attended more than one junior college, college, or university (including summer and special sessions) must present an official transcript from each institution. Failure to submit a complete report of academic experience will result in cancellation of admission or registration.

Those students wishing to enter in the spring semester should apply not later than November 1; fall semester applicants should apply no later than April 1.

Students may obtain applications by writing to the Transfer Section, Office of Admission, Alumni Memorial Building 27, Lehigh University, Bethlehem, Pa. 18015, or by telephoning (215) 758-3100.

When the receipt of the application is acknowledged by the office of admission, the student is advised of the time when transcripts and other documents should be submitted. Decisions on applications are reached soon after the middle of the semester preceding the one the student wishes to enter the university.

Estimate of Expense for Undergraduates

The operating expense of Lehigh University is supported principally by three areas of income: tuition and fees, endowment earnings, and gifts and grants. The university is conscious that educational costs are significant and strives to maintain a program of high quality instruction while recognizing that there are limitations on what families can afford to pay. The costs will vary somewhat from student to student depending upon the various options chosen.

Tuition, Room, and Board

There are three major plans that cover the major expense associated with university attendance. These are as follows:

The tuition plan. The university provides comprehensive academic and student services under its tuition plan. The tuition sum is inclusive of most athletic events, basic treatments in the Health Center, libraries, and laboratory services. An additional $200 fee is charged to sophomore, junior, and senior students enrolled in the College of Engineering and Applied Science or majoring in natural science. The full-time tuition rate is charged to students enrolled in twelve or more credit hours per semester. For students enrolled in less than twelve credit hours, tuition is charged on a per-credit-hour basis.

The residence halls plan. A variety of living arrangements are available. The university provides housing for 2,200 students on or near the campus in a wide selection of housing facilities. The housing arrangements are grouped within three basic categories, with rates associated with the category level. In order to guarantee a space within a residence halls unit, a $200 deposit is required for each semester. This deposit is credited toward the room charge for the respective semester. For entering freshmen, the deposit is not refundable if they make other plans. For returning students, the fee is refundable based upon a published schedule.

The board plan. Five board plans are available. The basic 21-Meal Plan is required for all freshman residents. Upperclass students living in residence halls have the option of participating in the Any-10-Meal Plan. Students residing in fraternities, campus apartments, or any off-campus facilities are eligible to participate in any of the plans. There is a special plan required for sororities located on the South Mountain campus.

Tuition and Fees

All charges and fees are due two weeks prior to the start of classes each semester. On a per-term basis, the expenses are charged at one-half the per-year charge. Accounts not settled by the due date are subject to a late-payment fee. All figures given are for the academic year (two semesters).

Tuition, 1987-88	$11,400
Residence Halls	
Category I (Dravo, Drinker, Richards, and McClintic-Marshall houses)	$1,960
Category II (Centennial Houses I and II, Packer House, and Warren Square)	$2,230
Category III (Trembley Park, Brodhead House, Gipson College, Hartman College, More College, and Taylor College)	$2,390
Board	
Plan A (21 meals per week, required of all freshmen)	$1,630
Plan B (any 10 meals selected throughout the week)	$1,420
Plan C (5 meals, lunch Monday through Friday)	$540
Plan D (5 meals, dinner Monday through Friday)	$880
Plan E (sorority plan of 5 breakfasts and 5 lunches Monday through Friday)	$1,000

Based upon the above charges, most freshmen are normally billed the tuition rate along with the Category I room fee and the Plan A food plan. The total cost for the three areas would be $14,990 for the 1987-88 academic year.

Other Fees (applied to prevailing circumstances)	
Per credit charge for credit and audit	475
Engineering and Science Fee (for specified students)	200
Application fee (for admission consideration)	35
Late preregistration	25
Late processing	50
Late registration	25
Late application for degree	25
Examination make-up (after first scheduled make-up)	10
Late payment (after announced date)	25
Returned check fine	10
Key penalty, residence halls (non-return)	10
Key duplicate, residence halls	3
Identification card (replacement)	10

The university reserves the right at any time to amend or add charges and fees, as appropriate, to meet current requirements. Fees applicable to the 1988-89 academic year will be announced no later than January, 1988.

Other Expenses

A student should plan to meet various other expenses. These expenses include the purchase of books and supplies from the Lehigh University Bookstore located in Maginnes Hall.

Necessary purchases supporting one's academic program should average approximately $350 per year. The bookstore carries basic goods for students' needs. A student should also plan an allowance to handle personal and travel expenses.

Plan of Payments

An itemized statement of charges is mailed from the bursar's office approximately six weeks prior to the start of each semester. Payment is expected in full by the specified due date. Payment plans are available for those desiring extended payment arrangements.

Persons desiring a payment plan can elect participation in either the Mellon Bank Edu-Check Plan, the Richard C. Knight Tuition Plan, or The Tuition Plan. Complete information is available from the bursar's office. Those persons desiring to use one of the plans must complete the necessary details no later than two weeks prior to the due date for payment.

Students attending the university under a provision with a state board of assistance or with financial aid from other outside agencies must provide complete information to the bursar's office if assistance is to be recognized on the semester statement.

Refunds of Charges

Tuition refunds. A student in good standing who formally withdraws (within the first eight weeks of a semester) or reduces his or her course enrollment below twelve credit hours will be eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

prior to the start of the semester	100%
during first calendar week	80%
during second calendar week	70%
during third calendar week	60%
during fourth calendar week	50%
during fifth calendar week	40%
during sixth calendar week	30%
during seventh calendar week	20%
during eighth calendar week	10%

Full-tuition refunds will be allowed for registration cancellations, or reductions in rosters, only in those instances when a notice is presented in writing to the registrar prior to the start of a semester. If the student has financial aid, he or she should consult the financial aid office as reductions in tuition charges may also result in a reduction of financial aid. Cancellation and reduction notifications received after the start of a semester will be recognized based upon the calendar week in which it is received by the registrar.

In the event of the death of a student, tuition will be refunded in proportion to the semester remaining. Any student suspended or expelled from the university will not be granted a tuition refund.

Residence halls refunds. Residence hall rooms are rented on an annual basis only. Refunds are made in full in the event a student does not register because of illness, injury, death, or is dropped from the university due to academic reasons. Partial refunds during the year are possible only in the event of a voluntary withdrawal and with the provision that the student can transfer the lease to another student for whom no other university accommodations exist.

Prorated refunds are based upon the date the room keys are returned to the residence operations office. An advance deposit of $200 for each semester is required to hold a room for the respective semester. This deposit is nonrefundable to entering freshmen and partially refundable to returning students based upon a published schedule.

Refunds for food plans. Board refunds are based on the number of unused days remaining in the board plan at the time the plan is discontinued. The prorated refund is based upon the date that official notification is received at the bursar's office. Refunds are granted based upon voluntary withdrawal, illness, or death.

Adjustments to financial aid. The office of financial aid is responsible for determining the appropriate redistribution of charges and refunds when students are in receipt of financial assistance. These decisions are made on the basis of university, federal, and state agency regulations. Adjustment procedures, where financial assistance (including GSL and PLUS loans) is concerned, are on file in the office of financial aid.

Financial Aid

The university offers financial assistance to U.S. citizens and permanent residents, based on financial need and academic promise. The competition for scholarship funds is keen; therefore it is important to read and understand the application procedures and to file the correct forms.

Lehigh expects that all families of its students will make every effort to pay tuition and other educational expenses. The aid program is focused to measure the dollar difference between the cost of attendance and the amount of money the family can contribute toward that cost. This difference is called "financial need." Most financial assistance is awarded on the basis of this calculated need.

Approximately 35 percent of the 1987 freshman class will enroll with university scholarships ranging, according to need, from $100 to $12,000. An additional 15 percent will enroll with aid from sources other than Lehigh, including state and federal grants, ROTC scholarships, aid from private sources, and guaranteed student loans.

There are four forms of financial aid available at Lehigh: scholarships, grants, loans, and employment. *Scholarships* are based on academic achievement and need not be repaid; most have financial need as a criterion for eligibility. *Grants* are based on financial need and satisfactory academic progress; they do not require repayment. *Loans* are borrowed from a variety of resources and are repayable at low interest rates after the student ceases to be enrolled. *Employment* provides money for books and personal expenses, with payment received as the student earns a salary at an hourly rate.

Additional sources of aid are state agencies, employers, and various clubs, churches, fraternal organizations, and foundations. High school guidance counselors may be able to provide information on local aid programs. Students are required to apply for all possible kinds of outside financial assistance, particularly the Pell Grant and state grant programs, which are important resources. Students are expected to take maximum advantage of outside sources to enable Lehigh spread funds farther and to limit student borrowing.

Application Procedures

Families of freshmen desiring financial aid file a Financial Aid Form (FAF) with the College Scholarship Service (CSS) between January 1 and 31 of the student's senior year in high school. Forms are normally available in guidance offices in December.

The Financial Aid Form is a two-sided document. Side I is used for Pell Grant and state grant review (except for Pennsylvania residents) and provides the basic data needed to determine federal and state eligibility. Side II requests additional information that is *required* by Lehigh. Pennsylvania residents are advised to use their Pennsylvania Higher Education Assistance Agency (PHEAA) application for requesting Pell Grant consideration.

All applicants should request that the College Scholarship Service send their analysis of the application form to Lehigh. The Lehigh code number is 2365. Applicants should also have the CSS send the information to both the Pell Grant program and the state scholarship agency (where appropriate). If the student is granted aid from Lehigh for 1987-88, a signed copy of the parents' and student's 1986 IRS Form 1040, with schedules, must accompany the acceptance. If possible, the tax returns should be sent as soon as prepared to help with the review of the FAF. Aid awards are not final until the FAF and Form 1040 are cross-checked. Award adjustments are made where differences in income and assets exist.

Additional forms are required of students whose parents are

divorced or separated. The student applicant and the parent with whom the student resides (i.e., the custodial parent) complete the FAF. If that parent is remarried, the stepparent's information must also be included. The other (non-custodial) parent is asked to complete the Divorced/Separated Parent's Statement. Lehigh requires this statement, and will mail it to the applicant soon after receiving the FAF, although it may be requested in advance.

Parents who are self-employed, or who own an income-producing farm, must file a Business or Farm Supplement, available from the office of financial aid.

Only the FAF and forms for special situations are required of incoming freshmen. Requests for a particular grant scholarship are not necessary. Receipt of the FAF establishes the student as an applicant for all types of financial aid, including federal aid administered by the university. Pell and state grant eligibilities are determined by those agencies.

Students who apply for early-decision admission for the 1988-89 academic year will receive an Early Version FAF from the office of financial aid. This form is filed with the CSS by November 15, 1987. Financial aid decisions, from completed applications, are made by December 15, 1987. Early-decision candidates have no advantage in the competition for aid, and are required to file the regular FAF between January 1 and 31, 1988, for purposes of federal and state aid. Residents of Pennsylvania file the PHEAA application, requesting Pell Grant consideration, prior to May 1.

Renewal of aid. It is necessary to reapply for financial aid for each year of study. Applications and filing instructions are available in mid-December in the office of financial aid, or as otherwise posted.

Upperclassmen file the FAF with the CSS by April 1. A Lehigh application form must also be completed and returned to the university's office of financial aid by April 1, accompanied by a signed copy of both the parents' and the applicant's 1987 IRS 1040 (with all schedules filed), as well as those additional forms required for special circumstances, such as the Divorced/Separated Parents Statement. Upperclass applications are not reviewed until the FAF, Lehigh application, and income tax forms are received.

In addition, to receive any type of aid a student must make satisfactory academic progress each year. University policy on satisfactory academic progress is available in the office of financial aid. Recipients of Lehigh grants and scholarships are expected to achieve at least the level of the all-university average (2.6). Students on academic or disciplinary probation are ineligible for university scholarship aid during the period of their probation. Students not maintaining satisfactory progress, as defined by Lehigh, are ineligible for all forms of federal aid, including loans and employment. Appeals based on extenuating circumstances are submitted to the committee on undergraduate financial aid.

Eligibility for financial aid is determined by calculating the amount a family can contribute to the cost of attendance based on income, assets, family size, number in college, and other factors. The expected contribution is then subtracted from the cost of attendance to yield "financial need."

A student's savings/investments and expectation of summer earnings are considered part of the family contribution. Incoming freshmen are expected to contribute $800 from summer earnings; expectations for returning and transfer students increase to $1,200.

In general, a student might be expected to have some need when the family's annual income and number of tax dependents (usually children) are as follows:

with one child at home	$45,000
with two children at home	$50,000
with three children at home	$55,000
with four children at home	$60,000

The figures above are for income before taxes and deductions, allowing for normal savings and home equity, with one child attending college. When more than one child is in college, the likelihood of financial aid is increased. Families with incomes as high as $75,000 are able to establish financial need if, for example, they have three children, all enrolled in independent universities like Lehigh.

Sources of University Aid

Several forms of university-funded aid, based on need and merit, are available.

Trustee scholarships. Funds are budgeted from general income to provide awards covering the tuition charges in whole or in part.

Sponsored scholarships. Individuals, foundations, and corporations provide these funds through annual contributions to the university. Lehigh has 44 such sponsors, with awards ranging from $300 to full tuition.

Endowed scholarships. Income from invested gifts to the university makes these scholarships possible. The university has 235 such funds, half of which are for general, unrestricted use. Most of the others are restricted by curriculum or geographic criteria.

Geographic Restrictions: Maryland, Delaware, Colorado, Ohio, Richmond, Va; Texas, Georgia, North Carolina, Tennessee, Kansas City, Mo; Hammonton, Kan.

College of Arts and Sciences: Geology and Geoscience, Premedical Science, Journalism and Science Writing.

College of Business and Economics: Accounting, marketing, economics, Allentown, Pa., residents, York County, Pa., residents.

College of Engineering and Applied Science : Applied mathematics, civil engineering, chemical engineering and chemistry, computer science, electrical engineering, industrial engineering, mechanical engineering, metallurgy, physics and engineering physics. New York City residents, Baltimore, Md., residents, western Pennsylvania residents.

Miscellaneous: Musicians (brass instruments); Gryphons; employees of U.S. Steel, Milton Roy Sheen, and Alperin Co.; members of certain fraternities.

Merit scholarships. Lehigh is a collegiate sponsor of the National Merit Scholarship program. Scholarships ranging from $500 to $2,000 per year may be awarded to Merit finalists selecting Lehigh as their first-choice college, and who are not also receiving another form of National Merit scholarship.

Athletic awards. Alumni Student Grants are awarded on the basis of financial need and exceptional athletic talent as evaluated by the department of intercollegiate athletics. Grants are supported by annual alumni contributions. ASG recipients refile the Financial Aid Form annually to determine the amount of their grant eligibility. In addition, there are a number of restricted endowed funds for use with intercollegiate sports participants.

University tuition loans. Parental endorsement is required on the promissory note. Repayment begins three months after graduation or withdrawal from the university, until the loan principal and interest are repaid. The minimum monthly repayment rate is $50 plus interest, which is 9 percent per annum, accruing only during the repayment period. Deferment is available for students who return to school at least half-time. Other deferments are available for students who are in the military, VISTA, or Peace Corps, up to a maximum of three years; or those who are experiencing undue hardship.

Lehigh maintains these loan funds to be used to supplement or replace other types of educational loans. The guiding factor in awarding university loans is that the combination of loans (federal, state, and institutional) shall not exceed one-half the cumulative tuition to be paid through the award period. If, for example, the total tuition over three years amounted to $30,000, a university loan would not be offered if total borrowing would exceed $15,000.

Loan-cancellation awards. This unique Lehigh award is used as an aid alternative for students whose academic average is not sufficiently competitive for scholarship consideration. L-C begins as a loan, with the same terms as Lehigh loans. The specified average must be earned during the award period of this award for the loan to be cancelled and replaced by a scholarship. If not cancelled, the loan is repayable according to the terms for university tuition loans.

Availability of jobs

Students may receive an employment allocation as part of their

aid package. In 1986-87, pay rates ranged from $3.35 to $3.90 per hour. Jobs are available throughout the university, and are funded through federal or university sources.

Aid recipients who do not receive a job as part of their aid package probably cannot earn more than $100 in outside wages without becoming "over-awarded," meaning that the sum of all resources exceeds computed need. "Over-award" status can lead to a reduction in an aid package.

Aid from the government

Students who apply for university aid are automatically considered for three programs sponsored by the U.S. Department of Education. Each year the university applies for funding for these programs. The number of awards is determined by the amount of money granted to Lehigh.

Supplemental Educational Opportunity Grants, ranging from $100 to $4,000, aid students of exceptional financial need.

Carl Perkins (National Direct Student) Loans enable the University to lend up to $4,500 for the first two years of undergraduate study, and $9,000 for all years of undergraduate study. Repayment begins nine months after graduation or withdrawal, and can be extended.

During the repayment period, 5 percent interest is charged on the unpaid balance. Deferments are available to students who return to school at least half-time, including professional internships. Other deferments are available for cases of undue hardship, and for those students active in the military, VISTA, or Peace Corps. Cancellation of all or some of the loan is available to students teaching in public schools appearing in the Federal Register, and to those students who suffer total disability.

The **College Work-Study** program subsidizes wages students earn in campus jobs.

Pell Grant. Students apply directly to the Federal Government for the Pell Grant program, which provides nonrepayable aid. Pell Grants for 1986-87 ranged up to $2,100.

State grants. Several states offer financial assistance that can be used in Pennsylvania. High school guidance personnel can provide information regarding eligibility and application procedures.

Pennsylvania residents may be eligible for grants ranging up to $1,750. Lehigh students also have received grants from Connecticut, Delaware, Massachusetts, Ohio, Rhode Island, and West Virginia.

ROTC scholarships. The departments of military science and aerospace studies award scholarships that provide payment for tuition, books, and other fees as well as $100 per month. Recipients incur an obligation to serve on active duty as commissioned officers in the Army or Air Force.

Guaranteed Student Loans. Applications for the Guaranteed Student Loans are available from lending institutions. Students applying through PHEAA (Pennsylvania Higher Education Assistance Agency) return their completed applications to the lending institution. Students applying through out-of-state lending institutions return their applications to the Lehigh office of financial aid. GSL eligibility is determined through the results of the Financial Aid Form. Students may borrow $2,625, less a loan-origination fee of 5 percent, for their freshman and sophomore years of study, and $4,000 per year for their remaining years of undergraduate study.

GSL recipients must maintain good academic standing and make satisfactory progress toward a degree. GSLs are repayable in monthly installments commencing six months after the borrower ceases to be enrolled at least half-time. Interest is currently eight percent per annum, for new borrowers, and is federally subsidized until the repayment period begins. Interest increases to 10 percent after the fourth year in repayment.

Deferment is available any time the borrower returns to at least half-time study in an approved program. A single deferment, for a period of not more than two years, is also provided for students who are unable to find full-time employment. In addition, borrowers do not have to make payment for up to three years while serving in the armed forces, Peace Corps, or in full-time volunteer programs conducted by ACTION. Several new deferments are now available for: the unemployed; women or maternity leave, teachers, single parents with disabled children, and active-duty members in the National Oceanic and Atmospheric Administration (NOAA).

The university recommends the GSL as part of most aid packages, reserving National Direct Student Loans and University Tuition Loans as a supplement to GSL where work-study funds are not available.

Supplemental Loans for Students / Loans for Parents. All students, except dependent undergraduates, are eligible for the Supplemental Loan Program. The loan limit is $4,000, with the cumulative limit at $20,000. The same annual and aggregate limits apply to the program of **Loans for Parents.** These loans can be used to cover the expected family contribution required in determining need in other financial-aid programs. A variable interest rate is established for both of these programs. Interest will be the one-year Treasury Bill rate, plus 3.75 percent, with a maximum of 12 percent.

PHEAA-HELP. All students attending Lehigh are eligible to borrow through the Pennsylvania Higher Education Assistance Agency. The Higher Education Loan Program (HELP) increases the annual borrowing maximum to $10,000, less any GSL based on a credit-worthiness check done by PHEAA. The interest rate is variable with a limit of 12 percent. The current rate is 9.5 percent. Specific information and applications are available from PHEAA and participating lenders.

Checklist for Financial Aid

1. *Returning students and transfer applicants only*: Submit the Lehigh application for undergraduate financial aid. Be sure to complete all questions.

2. The FAF should be completed by parents and applicants and submitted to the CSS, listing Lehigh University, CSS code 2365, in item 41, and answering "yes" to questions 43 and 44 to ensure both university and Pell Grant consideration. Forms are available from high school guidance counselors or the office of financial aid during December.

3. Submit a state grant application, particularly if you are a resident of Pennsylvania, Ohio, Massachusetts, Connecticut, Rhode Island, Maryland, Delaware, Vermont, or West Virginia.

4. Submit signed copies of the 1986 IRS form 1040, all pages and schedules, filed by student and parents. Income statements for those who will not file a 1040 are available from the office of financial aid.

5. Check to be sure your social security number is correctly listed on all forms. If you do not have a number, apply for one and notify Lehigh as soon as it is received.

6. For your records, photocopy the completed FAF and any other applications you submit.

7. *Transfers only*: Be sure to have your previous college(s) complete and forward the Financial Aid Transcript.

Campus Life

Approximately 85 percent of all undergraduate men and women are in residence in on-campus facilities. These take the form of residence halls, apartments, suites in a multi-story building, or residence in fraternity houses or sorority units. Physical facilities are also described in Section VI.

Residence Halls

The residence life office at Lehigh University is committed to providing quality housing and educational services to its resident students. Lehigh firmly believes that living in a residence hall allows students to become members of a special community, offering the opportunity to live with and learn from a diverse group of people. Efforts are made to integrate academic and out-of-the-class learning in order to enable students to develop a balanced and realistic approach to life after they leave the university.

When a candidate accepts an offer of admission to the freshman class, the candidate is sent a Room and Board Application-Contract. Those desiring accommodation in the residence halls must return this application-contract promptly. Priority of assignment is based on date of receipt of this application. A nonrefundable advance deposit of $200 must accompany the application and will be credited to the fall semester room charges. Normally, freshman room assignments are made in early August by the residence life operations office.

Currently, the demand for upperclass campus housing exceeds the supply by approximately 10 percent. For the duration of this imbalance, the University Forum has approved the use of a lottery to provide for fair and equitable distribution of available housing among upperclass students. The lottery is scheduled early in the spring semester. Those students who are guaranteed housing pay a $200 deposit to hold the space for the following academic year.

To help facilitate and maximize a student's residence experience, approximately ninety staff members of the office of residence life live in the residence halls. On every hall there is a student staff member, a Gryphon, who provides assistance in personal and academic matters, refers students to other offices where appropriate, helps mediate conflicts, and develops educational, social, and recreational programs. In addition to the student staff, graduate hall directors and full-time professional staff members live in the residence halls thus providing additional resources for students.

In every residence hall there are also House Councils that are part of the larger Residence Hall Council. Participation in the Residence Hall Council provides a chance to develop leadership, programming, human relations, and budgeting skills. It is a vital and active organization, whose prime focus is to help fund residence hall programs, to assess students' opinions on issues affecting them, and to develop many service-oriented programs to aid resident students in their stay on campus.

More than half of Lehigh undergraduates live in university residence halls. The university has eleven principal residence halls for undergraduate men and women. Most rooms are designed for two students, but a limited number of single, triple, or suite arrangements, and apartment units, are available. Residence halls offer a wide variety of special live-in programs including: four residential colleges, a German House, an International House, traditional-style living (in buildings with corridors), and suite/apartment-style living.

Fraternities and Sororities

The university has one of the strongest Greek systems in the nation. The continued strength of this system is due in part to the efforts of the Interfraternity Council, Panhellenic Council, the Greek Alumni Council, the office of the dean of students, and the fraternity services office to improve the quality of fraternity and sorority life through pledging, leadership, social, educational, housing, and financial management programs.

Greek life is an attractive alternative among the residence options at Lehigh. Each fraternity or sorority is a relatively small, close-knit community. These groups determine their own goals, manage their own houses and business affairs, conduct their own social, philanthropic, and athletic activities, plan their own meals, and select their own members. Because they are largely self-governing, these organizations offer numerous opportunities for student involvement and leadership.

The thirty-one fraternities and six sororities form a larger Greek community comprising approximately 45 percent of the undergraduate population at Lehigh. Through the Interfraternity Council (I.F.C.) and Panhellenic, they determine policies and organize social, philanthropic, and educational activities for the Greek community as a whole. In cooperation with the Forum, Student Activities Council, Residence Halls Council, and the office of the dean of students, the I.F.C. and Panhel also help to develop programs and policies for the wider university community.

There are six sorority chapters at Lehigh. They are housed in the Centennial I complex on the South Mountain Campus.

Twenty-seven of the fraternities are located on campus in Sayre Park. The remainder are located near the campus. The fraternities are Alpha Chi Rho, Alpha Epsilon Pi, Alpha Sigma Phi, Alpha Tau Omega, Beta Theta Pi, Chi Phi, Chi Psi, Delta Chi, Delta Phi, Delta Tau Delta, Delta Upsilon, Kappa Alpha, Kappa Sigma, Lambda Chi Alpha, Phi Delta Theta, Phi Gamma Delta, Phi Kappa Theta, Phi Sigma Kappa, Pi Kappa Alpha, Pi Lambda Phi, Psi Upsilon, Sigma Chi, Sigma Alpha Mu, Sigma Nu, Sigma Phi, Sigma Phi Epsilon, Tau Epsilon Phi, Theta Chi, Theta Delta Chi, Theta Xi, and Zeta Psi.

The University Forum

The Lehigh University Forum is a unique deliberative body whose purpose is to promote the welfare of the university and attainment of a true sense of community by bringing into discourse students, faculty, and administration.

Its membership includes elected representatives of the student body and of the faculty, and members of the administration (including the president, provost, vice president for student affairs and dean of students).

Four Forum representatives—two students and two faculty members—attend meetings of the board of trustees. Assured of access to the information upon which administrative decisions are based and free to inquire into any aspect of university operations, the Forum affords faculty and students a voice in university affairs equaled at few institutions.

The Forum has been particularly effective in the following areas: extracurricular activities and social life; planning that involves special educational opportunities; the academic environment; long-range planning and budget; and appointments at the level of dean or higher.

Three Forum committees—academic environment, administration, and campus life, are each jointly headed by a faculty member and a student. Numerous subcommittees work on specific issues, allowing Forum members either to work on a broad range of topics or to concentrate on particular aspects of university life they find most important. Many non-Forum students also work actively on subcommittees, and in some cases serve as chairpersons. This participation provides valuable background and experience for later candidacy to the Forum or other elective positions.

The Forum also appoints student members to certain standing committees of the faculty and certain ad-hoc university committees when invited.

All meetings of the Forum are open to the university community, with the right to address the Forum provided to any person desiring to do so. The Forum office is located in Packer Hall, the university center, and students are invited to come in to discuss any aspect of university government.

Honorary and Course Societies

There are at least fifteen honorary and course societies. The three best-known are:

Phi Beta Kappa. The oldest national scholastic honorary society (founded December 7, 1776, at the College of William and Mary) recognizes high academic achievement as well as a breadth of interest in the liberal arts and the natural and social sciences. Admission to its ranks is also held to indicate potentialities of future distinction. The Lehigh chapter was chartered in 1887 as Beta of Pennsylvania.

Beta Gamma Sigma. Election to membership in Beta Gamma Sigma is the highest scholastic honor that a student in

business administration can achieve. Beta Gamma Sigma is the only national honorary scholarship society in the field of business administration recognized by the American Assembly of Collegiate Schools of Business.

Tau Beta Pi. Tau Beta Pi recognizes high achievement in all engineering curricula. The national Tau Beta Pi was founded at Lehigh in 1885. A bronze marker in front of Williams Hall commemorates this event.

Among course societies are the following: Alpha Pi Mu, for those in industrial engineering; Beta Alpha Psi, accounting; Chi Epsilon, civil engineering; Eta Kappa Nu, electrical engineering; Lambda Mu Sigma, marketing; Omicron Delta Kappa, leadership; Phi Alpha Theta, history; Phi Eta Sigma, freshman scholastic excellence; Pi Tau Sigma, mechanical engineering; Psi Chi, psychology; Sigma Tau Delta, English; and Sigma Xi, research.

Religious Activities

The religious program is under the general supervision of the university chaplain. The chaplain also provides for Protestant chapel services, broadly based and ecumenical in form, varying from the traditional to the informal and innovative. Some services feature the university choir; others, folk music. Roman Catholic masses are arranged by the Newman Association Center chaplain. Packer Memorial Church is the center for campus worship services. Given in honor of Lehigh's founder, Asa Packer, the chapel will celebrate its centennial during 1987.

Protestant and Roman Catholic service schedules are announced at the beginning of the year. Jewish services are available nearby in the community. Attendance at all religious services is voluntary. The university is nondenominational.

The university chaplain works with representatives from campus religious groups of all faiths and jointly sponsors a variety of programs together with those organizations. The chaplain's office has sponsored, in addition, luncheon programs and a film series, both with discussions; talks by religious leaders (including recently Bishop Desmond Tutu of South Africa and Elie Wiesel, author and Holocaust survivor) and faculty members; and multi-media presentations. The programs are open to all students.

The Newman Association offers a program for Catholic students under the guidance of a priest. The association has its own building on campus.

The Hillel Foundation supports a program for Jewish students including a Hillel House as a focus of activity.

Protestant students have a variety of fellowship programs available to them, both on campus through the Lehigh Christian Fellowship, the Navigators and other groups, and off campus with the various churches nearby.

Student Organizations

Lehigh offers a wide field of extracurricular activities and student organizations. There is a campus radio station, a twice-weekly student-run newspaper, a dramatic club, musical organizations, and many other opportunities for participation. Course societies promote intellectual interest in various fields of study and develop professional spirit among students.

Interest and hobby groups include art, ballet, band, chess, camera, computer, languages, rugby, sailing, skiing, boxing, judo, model railroading, political clubs, fencing, and waterpolo. These are described in the *Lehigh Handbook,* which is distributed to all students.

Many students also are elected to honorary societies and others join course societies.

Theater at Lehigh

The division of speech and theater sponsors play productions that provide opportunities for onstage or backstage participation. In conjunction with the Mustard and Cheese Dramatics Society, founded in 1884, four mainstage productions are undertaken annually in the Wilbur Drama Workshop, ranging in style from the classics to the *avant-garde.*

Recent productions have included "*Tartuffe,*" "*The Roar of the Greasepaint—The Smell of the Crowd,*" "*The House of Blue Leaves,*" "*Oedipus Rex,*" "*Fifth of July,*" "*Hedda Gabler,*" "*A Midsummer Night's Dream,*" and "*Waiting for Godot.*" Students act, work behind the scenes and sometimes design and direct with full theater faculty participation. For the general student population, participation in a production is an extracurricular activity combining artistic and social interaction.

Independent student work is promoted and encouraged through the Lab Theatre program. Located in Coppee Hall, the Lab Theatre is dedicated to student exploration of the relationship between performers and text. "*The Carpenters,*" "*The Maids,*" "*Sister Mary Ignatius Explains It All For You,*" "*The Zoo Story,*" "*Miss Julie,*" "*Tintypes,*" "*Doctor Faustus,*" and "*The Mousetrap,*" are recent student-directed Lab Theatre productions.

The division sponsors touring professional productions, adding to the cultural life of the campus. These productions have included performances by the National Theatre of the Deaf and The San Francisco Mime Troupe as well as residencies by the Pennsylvania Dance Theatre and Touchstone Theatre. A popular London-Paris Theatre tour is offered annually.

Musical Organizations

The university sponsors both a variety of student musical organizations that give performances on and off campus and a professional concert series, Music at Lehigh, that brings visiting artists to the campus. The choruses, bands, orchestra, and ensembles are conducted by members of the faculty and managed by elected student leaders.

Christmas Vespers and Spring Vespers are traditional choral performances. The university choir has toured Canada, Puerto Rico, the Virgin Islands, Washington, D.C., and throughout Pennsylvania.

The Choral Union, formed in 1985, performs major works with orchestra. It is open to all students, faculty, and staff as well as members of the community.

The concert band plays winter band concert and a pops concert on campus in the spring. The concert band has performed on tour in Florida, Washington, D.C., and on the campuses of other colleges and universities. The concert band also sponsors a jazz ensemble that performs on campus and plays at jazz festivals around the country.

Performances by the string orchestra and the ensembles traditionally close the semester concert season. The ensembles include groups of string, brass, woodwind, percussion and mixed instruments. Recent additions have been ensembles of Renaissance instruments from the university collection.

The Lehigh University Very Modern Ensemble (LUVME) combines students, faculty, and professional musicians who perform the music of the 20th Century. LUVME also sponsors concerts of music by Lehigh student composers and annually brings a composer of national reputation to campus in order to discuss and play his/her music.

The "97" marching band is widely known for its imaginative and spirited performances on the gridiron and in the stands in support of the Lehigh football team. Pregame and half-time performances are precision drills with a varied repertoire from classical music to traditional fight songs. The band is comprised of 97 men and women with nine students serving in executive positions.

The concert series Music at Lehigh presents a variety of concerts and recitals. Among the artists who have appeared are the Orpheus Chamber Orchestra; Calliope: A Renaissance Band and Dawn Upshaw, Met soprano. Inaugurated in 1980, the Ralph Van Arnam Chamber Music Series presents concerts of outstanding chamber music; the series honors the memory of a Lehigh faculty member.

Private instrumental and vocal lessons with instructors approved by the music department are open to all students. The cost of lessons is in addition to tuition expense.

Volunteer Services

Varied opportunities for student expression of social responsibility exist through programs sponsored by the Lehigh University Volunteers (LUV). Typically, more than 100 students participate in volunteer-service efforts in the Lehigh Valley area in a range of service programs. LUV is governed by a board composed of coordinators of its various projects.

Most of the volunteer work is done in cooperation with community agencies or schools. Some of the projects include tutorial programs in public and private schools, assistance in several local hospitals, Big Brothers, companionship, and group work with children and adults in residential mental-health treatment facilities, aid to the elderly in institutions and at home, blood assurance, and individual and short-term efforts.

LUV's office is located in Packer Hall, the university center.

Guest Speakers

Students have the opportunity to hear a wide variety of notable speakers. The speeches are offered free of charge. Many of the speakers appear under the auspices of the Visiting Lecturers Committee. Committees with access to special funds and academic departments regularly offer presentations by scholars from various disciplines. In addition to delivering a formal address, the speakers are often invited for brief residencies to provide opportunities for more informal interaction with students.

Among those to visit the campus have been attorney F. Lee Bailey, philosopher Derek Parfit, actor Vincent Price, South Africa's Bishop Desmond Tutu, and novelist John Irving. Thomas Armstrong, director of the Whitney Museum, spoke with students during a week-long residency. An Engineering Expo with speakers representing many prominent industries featured Peter Bridenbaugh, vice president of science and technology, Alcoa. From art to engineering, the campus stays in touch with current issues, trends, and movements through its many and varied speaker series.

Athletic Opportunities

There are numerous athletic programs offered to students on the intercollegiate and intramural and recreation level.

Athletic facilities are afforded in Taylor Gymnasium, Grace Hall, and Taylor Stadium, as well as on the Murray H. Goodman Campus, located two miles south of the main campus. The 500-acre Goodman athletic complex includes the Stabler Athletic and Convocation Center, which seats 6,000 and is the location for many home contests of the wrestling and men's basketball teams. Also located there is the Philip Rauch Field House, which includes a one-eighth-mile track, and indoor tennis and basketball courts. There are football, soccer, field hockey, and lacrosse fields, baseball and softball diamonds, indoor squash courts, and a cross-country course, and an all-weather outdoor eight-lane 400-meter track.

Intercollegiate Athletics

The intercollegiate varsity-level sports for men and women include the following. **Fall:** Football, men's and women's cross-country, soccer, women's field hockey, and women's volleyball. **Winter:** men's and women's basketball, wrestling, indoor track, men's and women's swimming, and rifle. **Spring:** Baseball, outdoor track and field, men's and women's tennis, women's softball, men's and women's lacrosse, golf.

During the 1985-86 season Lehigh teams compiled 183 wins to 200 losses and three ties. Women's sports won 82 and lost 87, plus one tie for a 48.5 percentage. Men's sports won 101 and lost 113, plus two ties, for a 47.2 percentage. Over-all, eleven teams enjoyed winning seasons, and two teams finished with a .500 record. Women's basketball won the ECC title and set a school record of 24 wins against four losses. Women's tennis won their fourth straight ECC fall tournament title.

During the 1985-86 season, Lehigh hosted the following championship events: East Coast Conference field hockey, East Coast Conference golf, EIWA wrestling, and 1C4A cross-country.

Intramural Athletics

The department of intramural sports and recreation supervises some 26 intramural sports and the recreational physical activities of students. The aim is to insure the health and physical development of students.

Through its program of intramural sports, the university endeavors to maintain among its students a high degree of physical fitness, to establish habits of regular and healthful exercise, to foster the development of such valuable byproducts as self-confidence, good sportsmanship, and a spirit of cooperation, and to provide each student with ample opportunity for acquiring an adequate degree of skill in sports of the type in which participation can be continued after graduation.

On a club-level, there are from 20 to 25 common-interest groups ranging from karate and judo to Frisbee and floor hockey. Some of the clubs have as few as ten members and students who have a special interest of their own are encouraged to pursue it.

Also available are instructional classes in aerobics, slimnastics, and skiing, in addition to such special tournament events as foosball, innertube waterpolo, and three-on-three basketball. The intramurals office provides picnic bags filled with bats, softballs, and other recreational equipment. The facilities in Taylor Gymnasium and Philip Rauch Field House are also available at listed times.

Guide to Academic Rules and Regulations

The university, like the rest of society, has adopted over the years numerous rules and regulations. Some of the principal rules and regulations are given here so that currently enrolled and potential undergraduates and graduate students will be apprised of what is expected of them, and what they can expect of the university.

This section concerns academic regulations. Additional regulations can be found in the *Lehigh Handbook*, and there is a comprehensive statement of all policy in the publication *Rules and Procedures of the Faculty*. All students are given a *Handbook* at the beginning of the fall semester; *Rules and Procedures* is available in the university libraries and in departmental and administrative offices.

Eligibility for Degree

In order to be graduated, a candidate for a baccalaureate degree must achieve a minimum cumulative average of 1.70.

To be eligible for a degree, a student must not only have completed all of the scholastic requirements for the degree, but also must have paid all university fees, and in addition all bills for the rental of rooms in the residence halls or in other university housing facilities. Payment also must have been made for damage to university property or equipment, or for any other indebtedness for scholarship loans or for loans from trust funds administered by the university.

Responsibility for meeting requirements. A student is responsible for consulting with the academic adviser or department chairperson, prior to the senior year, to ascertain scholastic eligibility for the degree for which this student desires to qualify and to determine that all program and credit hours requirements will be met.

Final date for completion of requirements. For graduation, all requirements, scholastic and financial, must have been satisfied prior to the graduation exercises.

Notice of Candidacy for Degree

Candidates for graduation on University Day in May or June file with the registrar on or before March 2 a written notice of candidacy for the degree; candidates for graduation in January file a notice of candidacy on or before December 1; candidates for graduation on Founder's Day, the second Sunday in October, file a notice of candidacy on or before September 1.

Failure to file such notice by such dates mentioned debars the candidate from receiving the degree at the ensuing graduation exercises. If a petition for late filing is granted, a fee is assessed.

Graduating Theses

Undergraduate theses, when required, are accompanied by drawings and diagrams, whenever the subjects need such illustration. The originals are kept by the university, as a part of the student's record, for future reference; but copies may be retained by students and may be published, provided permission has first been obtained from the faculty.

Undergraduate Credit and Grades

A semester hour of college work consists of one hour a week of lectures or classwork, or two or three hours of laboratory work per week (or laboratory work combined with classwork) for one semester. The normal assumption is that the student will be expected to do at least two hours of study in preparation for each hour of classwork. The term "semester hour" is used interchangeably with "credit hours."

Latest date for registration. No registration is accepted later than the tenth day of instruction in any semester.

Definitions of grades. Course grades are A, A−, B+, B, B−, C+, C, C−, D+, D, D−, P, F, N, and X. The meaning of each grade is as follows: A, A−, excellent; B+, B, and B−, good; C+ and C, competent; C−, continuation competency (the student has achieved the level of proficiency needed for the course to satisfy prerequisite requirements); D+ D, and D−, passing, but in the estimate of the teacher, the student may not be adequately prepared to take any subsequent course that has the teacher's course as a prerequisite. A student must obtain his or her adviser's permission to use courses in which a grade of D+, D, or D− is received to meet prerequisite requirements; P, pass-fail grading with a grade equivalent to D− or higher; F, failing; N, incomplete; X, absent from the final examination; XN, absent from the final examination and incomplete.

Other symbols used for courses on student records are: Cr, credit allowed; W, withdrawn; WP, withdrawn with permission and with passing performance at the time of withdrawal; WF, withdrawn beyond the deadline and/or with failing performance.

Grades in the range of A through D−, P, and Cr may be credited toward baccalaureate degrees within the limits of program requirements. Grades of F, N, X, XN, W, WP, and WF cannot be credited toward the degree. Grades of F and WF that have not been bettered through repetition of the course must be included in computation of hours attempted. Grades of W and WP do not count as hours attempted.

Courses in which grades of F, W, WF, N, X, or XN are recorded do not meet prerequisite requirements.

The grade N(grade) may be used to indicate that one or more course requirements (e.g., course report) have not been completed. It is the obligation of the student to explain to the satisfaction of the instructor that there are extenuating circumstances (e.g., illness or emergency) that justify the use of the N grade. If the instructor feels the N grade is justified, he or she assigns a grade of N supplemented by a parenthetical letter grade, (e.g., N(C)). In such cases, the instructor calculates the parenthetical grade by assigning an F (or zero score) for any incomplete work unless he or she has informed the class in writing at the beginning of the course of a substitute method for determining the parenthetical grade.

In each case in which an N grade is given, the course instructor shall provide written notification to the department chairperson stating the name of the student receiving the grade, the reason for the incomplete work, the work to be done for the removal of the N grade and the grade for the work already completed.

A student who incurs an N grade in any course is required to complete the work for the course by the fifth day of instruction in the next academic-year semester. The N grade will be converted into the parenthetical grade after the tenth day of instruction in the next academic-year semester following receipt of the N grade unless the instructor has previously changed the grade using the removal-of-incomplete procedure. The parenthetical grade will be dropped from the transcript after the assignment of the course grade.

In no case shall the grade N be used to report absence from a final examination when all other course requirements have been met.

N grades do not count as hours attempted and are not used in computations of cumulative averages.

The grade X (grade) is used to indicate absence from the final examination when all other course requirements have been met. The grade in parenthesis is determined by including in the grade calculation an F (or zero score) for the missing final exam. The X grade may be removed by a make-up examination if the absence was for good cause (e.g., illness or other emergency). To be eligible for the make-up exam, the student must file a petition and the petition must be approved by the committee on standing of students. If the student fails to petition, or if the petition is not granted, or if the student fails to appear for the scheduled make-up examination, then the X grade will be converted into the parenthetical grade after the first scheduled make-up examination following the receipt of the X grade. If the petition is granted and the final examination is taken, the X grade will be changed by the instructor using the make-up examination procedures and the parenthetical grade will be dropped from the transcript.

Where there are valid reasons for not taking the make-up examination at the scheduled time, the student may petition for a later examination with a fee.

The grade XN (grade) is used to indicate both absence from the final examination and incompletion of one or more course requirements. The instructor calculates the parenthetical grade using an F (or zero score) for the final examination and either an F (or zero score) or the substitute method of calculation as described above for the incomplete work.

The XN grade may be removed by the procedures presented in the previous paragraph for removing the X grade. If this results in an N grade because the course work is still incomplete, the provisions Incomplete (N grade) above shall apply, except that in no case shall the deadline for completion of the work be later than the last day of classes in the first full semester in residence (except summer) following receipt of the XN grade.

Where failure to complete coursework prevents the student from taking the make-up examination at the scheduled time, the student may petition the committee on standing of students for a later examination.

An XN grade that is still outstanding after the tenth day of instruction in the next academic-year semester following receipt of the XN grade will be converted into the parenthetical grade. The parenthetical grade will be dropped from the transcript.

X and XN grades do not count as hours attempted and are not used in computations of cumulative averages.

A withdrawal from a course within the first ten days of instruction is not recorded on the student's record.

A student wishing to withdraw from a course after the tenth day, but not after the ninth week of instruction, must proceed as follows: The student indicates intention in writing to withdraw from the course, giving the course number, title, and credit hours; the student presents the drop and add form to the adviser and the course instructor. Each signs the form to indicate that he or she has seen it and discussed it with the student, and notes appropriate recommendations; the signed form is delivered to the registrar. He or she records a W for the course and the date of withdrawal on the student's transcript.

A student who officially withdraws from the university through the ninth week of instruction receives grades of W in the courses for which he or she is registered. Thereafter, each

course instructor assigns a grade of WP or WF.

A student who withdraws from a course but not the university after the ninth week of instruction will automatically receive a WF for the course.

A student who reduces his or her course load below the minimum required for standing as a full-time student but does not withdraw from the university becomes a part-time student for the rest of that semester. Some areas affected by part-time status are financial aid, athletic eligibility, veterans affairs, selective service, and immigration status.

Official reports of grades are issued to advisers and students by the registrar as soon as possible following the deadline for reporting of grades. Instructors may develop their own policies for release of unofficial reports of academic progress to individual students, or to their advisers, deans, or financial aid officers, on a need-to-know basis, including early release of unofficial final course grades. Any such policies must respect the rights of students to privacy.

A report of grades is sent to each student's home at the end of every semester.

Graduate Credit and Grades

Course grades are defined as for undergraduates except that no grade lower than C− may be counted toward a graduate degree and pass-fail registration is not allowed for graduate students. No student who receives more than four grades below a B− in courses numbered 200 or higher is allowed to continue registration as a graduate student.

The N grade is defined as for undergraduates except that graduate students have a calendar year to remove course incomplete grades unless an earlier deadline is specified by the instructor. Graduate student incomplete course grades that are not removed remain as N grades on the student's record. Thesis or research project N grades may remain beyond one year until the work is completed.

The X grade is defined as for undergraduates except that to be eligible for a make-up examination a graduate student must file a petition and the petition must be approved by the graduate committee.

The XN grade is defined as for undergraduates except that graduate students have a calendar year to complete coursework following an XN grade unless an earlier completion deadline is specified by the instructor. The X portion of the grade is removed as described for undergraduates. XN grades which are not removed remain on the record of graduate students. All petitions for exceptions are sent to the graduate committee.

A withdrawal from a course within the first ten days of classes is not recorded on the student's record.

A student who wishes to withdraw from a course after the tenth day, but not after the ninth week of instruction, receives a grade of W. A student who withdraws after the ninth week period will receive a WF or WP at the discretion of the instructor.

A student withdrawing from a course submits a department approved change of roster form to the Graduate School office.

Pass-Fail Systems for Undergraduates

Student Option System. The pass-fail grading option is intended to encourage students to take challenging courses outside the major field that otherwise might be avoided for fear of lowering grade-point averages. Students should avoid wasting this option on unsuitable courses, such as introductory courses having no college-level prerequisite or corequisite. The restrictions on the use of the system are listed below.

A student may register for no more than two courses pass-fail in any one semester. He or she may take a maximum of six courses pass-fail per undergraduate career if the student is on a four-year program, or a maximum of eight courses per undergraduate career with a five-year, two-degree program. If a student changes a course after the first ten days of instruction from pass-fail grading to regular grading, as provided below, that course shall still count toward the maximum number of courses taken pass-fail during the student's undergraduate career.

Each college faculty shall decide under what conditions and which courses or categories of courses throughout the university may be taken for pass-fail credit by students registered in that college, except for courses designated specifically for pass-fail grading. Each college shall keep the educational policy committee advised of changes in its rules.

A student designates the course(s) to be taken pass-fail normally at preregistration but not later than the tenth day of instruction in a regular semester or the fifth day of instruction in any summer session. Prior to this deadline, the student may transfer from pass-fail to regular grading, or vice-versa, without penalty. After this deadline, the student cannot transfer from regular grading to pass-fail grading; however, the student may transfer from pass-fail grading to regular grading through the ninth week of instruction. The courses designated for pass-fail grading by the student require the written acknowledgement of the academic adviser.

The instructor giving the course is not officially notified which students are taking the course pass-fail. Therefore, a regular letter grade is reported for the pass-fail students. The registrar then records "P" for reported letter grades from A through D−, and "F" for a reported letter grade of F.

Under this system, the student surrenders his or her equity to letter grades of A through D−, except as specified below. A grade of P applies to the student's graduation requirements but is not used in the computation of the cumulative average. An F grade is computed in the normal manner.

If a student changes his or her program such that a course previously taken for pass-fail grading is not allowed for pass-fail grading in the new program, the student must submit a petition to the committee on standing of students requesting acceptance by the new program of the pass-fail grading for that course, or substitution of the original letter grade submitted by the instructor for the pass-fail grade, or the substitution of another course for the course taken pass-fail. The recommendation of the adviser must accompany the petition.

Courses at the 400 level are excluded from pass-fail grading.

Grade Values and Probation

Effective August 31, 1983, the scholastic requirements for undergraduate students will be expressed in terms of the cumulative average—the weighted point average of all grades received in residence or at institutions specifically approved for grade transfer. The cumulative average is computed at the end of each semester and the second summer session. The following cumulative average requirements for good standing are in effect:

freshmen	1.50
sophomores	1.60
juniors and seniors	1.70

For purposes of computation, students who have completed fewer than 22 hours of coursework shall be required to maintain a 1.50 average to remain in good standing. Students who have completed 22 hours but fewer than 52 hours shall be required to maintain a 1.60. Other students shall be required to maintain a 1.70—the average required for graduation—to remain in good standing.

Students who do not meet the above requirements will be placed on scholastic probation. Students who, regardless of their cumulative average, have failed more than eight hours of course work in any semester are also placed on scholastic probation.

While there are no hours requirements for good standing, certain categories of students (e.g., those on financial aid and those playing intercollegiate athletics) will be expected to maintain whatever hours are required for eligibility.

Removal from probation. Students are removed from probation at such time as they meet the standard listed above, effective at the end of any semester or the second summer session.

Dropped for poor scholarship. A student who makes a 2.2 average or better in the probationary semester but fails to meet

the standards stipulated is continued on probation for another semester. A student who makes less than a 2.2 average in the probationary semester and fails to meet the standards stipulated above, is dropped for poor scholarship.

If a student goes on scholastic probation for the second but not consecutive term, a review by the committee on standing of students will determine whether the student will continue on scholastic probation or be dropped for poor scholarship.

Honors Opportunities

There are several kinds of honors awarded to undergraduates. Each department offers departmental honors to qualified students and each college offers an honors program as well; more information is contained in Section III.

Graduation honors. Degrees *with honors* are awarded by vote of the university faculty to those students who have attained an average of not less than 3.25 in their sophomore, junior, and senior years of work at the university, and in not less than seventy-two hours of work graded A, B, C, D, or F.

Degrees *with high honors* are awarded by vote of the university faculty to those students who have an average of not less than 3.50 in their sophomore, junior, and senior years of work at the university, and in not less than seventy-two hours of work graded A, B, C, D, or F.

Degrees *with highest honors* are awarded by vote of the university faculty to those students who have an average of not less than 3.75 in their sophomore, junior, and senior years of work at the university, and in not less than seventy-two hours of work graded A, B, C, D, or F.

Graduation honors are announced on University Day and on Founder's Day.

For special cases. Students who spend all or part of their sophomore, junior, or senior years at another institution may qualify for graduation honors under the following conditions:

1. The student must have at least ninety credit hours of work at Lehigh and an average during the last six semesters in residence at Lehigh that qualified him or her for graduation honors. This average determines the highest category of graduation honors that is possible for the student to attain.
2. The student's average at the other institution when computed with the last six semesters at Lehigh must be such as still to qualify the student for graduation honors. This average may lower the over-all average of the student from one category of graduation honors to another one.

Graduation honors are published in the commencement program.

In all cases, it is required that each student have not less than seventy-two hours of work graded A, B, C, D, or F, including plus + or minus − designations.

In computing the averages of candidates for graduation honors, semester grades are weighted according to the number of credit hours in the course concerned.

Review-Consultation-Study Period

The Review-Consultation-Study (RCS) period is intended to provide a few days for informal academic work between the end of the formal instruction period and the beginning of the final examinations.

It is expected that students will use this period to consolidate their command of the material in their courses. Faculty members make themselves available to their students at announced times during the period; for example, at the hours when they ordinarily meet classes for instruction.

No quiz may be given during the eight-day period before examinations.

Good Citizenship

The university exists for the transmission of knowledge, the pursuit of truth, the development of students, and the general well-being of society. Free inquiry and free expression are indispensable to the attainment of these goals. All members of the academic community are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth.

Out of concern for individuality and respect for the privacy of all persons, the university does not impose a common morality on its members. Institutional existence, however, is a privilege granted by public trust, subject to the sanctions and responsibilities defined by the society of which the university is a part.

Furthermore, society generally provides legal canons, ethical mores, and conduct expectancies pertaining to individual and collective behavior. Thus, the university has the obligation to establish standards of conduct appropriate and applicable to the university community.

Lehigh accepts its responsibility as an institution within the broader social community. The standards of behavior expected of its members are those that the university regards as essential to its educational objectives and to community living.

In accordance with these purposes and objectives, disciplinary action will be taken when necessary to protect the academic integrity of the university and the welfare of its members.

All members of the university community are subject to municipal, state, and federal laws. Obviously the university cannot be a sanctuary for persons who violate these laws. Lehigh is concerned, however, about the rights of students as citizens and will direct them to legal counsel when necessary.

While off-campus misconduct will not normally be the basis for disciplinary action, where the university has an identifiable interest separate from that of the off-campus community, such conduct may be subject to disciplinary review and action by the university.

Further, the university as a part of the community has an obligation to report serious crimes to civil authorities.

Lehigh relies primarily on general principles and statements of expectation for standards of conduct, and assumes that those admitted to the university community are capable of accepting that responsibility. Specific regulations are kept to a reasonable minimum and are published in the *Lehigh Handbook*. Students are responsible for knowing the procedures, rules and regulations as published in the *Handbook*.

Policy on Dissent

Regarding dissent, the university faculty has a policy that emphasizes the responsibility of all members of the university community. The guidelines adopted broadly set forth acceptable forms of dissent on campus.

Generally, the policy on dissent provides the following:

1. Free inquiry and free expression, including the right to open dissent, are indispensable in achieving the goals of an academic community.

2. Coercive activities employed by individuals or groups either to repress legitimate dissent or to demonstrate dissent are a threat to the openness of the academic community and will be dealt with as an extremely serious matter.

3. Where physical coercion is employed or physical obstruction persists and the university is prevented from resolving the matter through its established disciplinary procedures, legal sanctions will be employed.

This statement provides that orderly and peaceful demonstrations on campus are not forbidden unless they interfere with legitimate university functions. The authority for making the initial judgment in determining the permissible limits of protest rests with the president and counsel of an advisory committee consisting of four faculty members and four students.

Conduct that exceeds permissible limits will be met with university sanctions ranging in severity from admonition to expulsion, or in cases of aggravated or persistent violation of defined rights, with civil arrest and prosecution under an appropriate charge. Prime authority for discipline rests with the faculty and the university committee on discipline.

Nontraditional Students

Adults and other nontraditional students who desire access to regular university courses have a number of options available. They may apply for admission to an undergraduate or graduate degree program on a full or part-time basis.

If they need to take one or more courses for credit, but are not seeking a degree, they may seek admission to the General College Division on the undergraduate level or become associate graduate students on the graduate level.

"Steam Laboratory—Flickinger 1905." The old steam generating plant is now known as the Wilbur Drama Workshop.

II.

University Resources

Lehigh's students can enhance their education by taking advantage of a variety of university resources. These range from classrooms and laboratories with modern equipment, to expert faculty members and extensive library collections. In addition, the university's three continguous Bethlehem campuses encompassing 1,600 acres provide a beautiful environment for learning. This section describes the university's academic resources and its resources that serve the special needs of students.

Collections and Computers

The directness of the printed word, the vision of art, and the power of data processing all play important roles in a broad, liberal education. University collections and facilities place a wealth of information at the student's disposal.

Libraries

The university library system serves as an essential element in the educational process, providing users access to information not only through an extensive book and journal collection numbering more than 850,000 volumes, but through electronic data bases, microform, computer software, and media collections as well.

In 1986, the libraries are well on the way to completing the transformation from the traditional paper library to an electronic information center. Users may access the on-line catalog, known as ASA (Automated System Access), from every residence-hall room, every faculty office, classrooms, and laboratories, via the campuswide network. Users also may obtain worldwide access to several hundred national and international electronic data bases.

Facilities and Collections

With the opening in 1985 of the E.W. Fairchild-Martindale Library and Computing Center, adjoining the Mart Science

and Engineering Library, the combined information center has merged more than 250,000 volumes in the social sciences with a 185,000-volume collection in the natural and physical sciences, mathematics, and all branches of engineering. The new facility, which has a total capacity of 650,000 volumes, also houses government documents and business collections.

The historic Linderman Library, part of which was built in 1877, is dedicated to all branches of the humanities. A collection of 340,000 volumes encompasses strengths in British colonial history, and American and English literature. The Bayer Galleria of Rare Books, which opened in 1985, embraces the university libraries' Special Collections Division, estimated to include about 24,000 volumes. Included here are the extensive rare-book collections, many of which were donated by the libraries' benefactor, Robert B. Honeyman, as well as university archives, and Congressional papers. Noteworthy among the treasures in the rare book collection are an original edition of John James Audubon's *Birds of America* and three copies of the first edition of Charles Darwin's *Origin of Species*.

Resources

Library holdings represent a rich resource for the university community. In addition to the collection of 850,000 volumes, the libraries receive more than 9,000 periodicals and serials, including a well-developed foreign and domestic newspaper collection. Another important research tool is the government documents collection. A partial government depository since the 19th Century, the libraries hold more than 180,000 federal, Pennsylvania, and United Nations documents, as well as a vast collection of technical reports from governmental agencies.

Nonprint collections of nearly 650,000 microforms and 15,000 audiovisual resources enhance the traditional book and journal collections. The David M. Greene music collections includes several thousand tapes and cassettes of classical music. The libraries also have InfoTrac, an optical disk system offering a data base for retrieval of current literature.

University library resources are augmented by memberships in the Lehigh Valley Association of Independent Colleges; PALINET, Pennsylvania Area Library Network; IDS, Interlibrary Delivery Service of Pennsylvania; OCLS, Online Computer Library Center; as well as the International Association of Technological University Libraries.

Services

The university library staff, numbering more than 65 full-time employees, serves the needs of faculty and students by providing programs that stimulate the use of the information system as a vibrant intellectual resource. Helpful personal assistance is available from staff in such areas as computer searching of remote data bases; instruction in research bibliographic methodology; library orientation; current-awareness services; and interlibrary loans. Since the advent of the campuswide network, and the ease of accessing electronic information, the reference staff has been providing a major instructional effort for end-user searching of both local and remote data bases.

As a convenience to the university community, the libraries have available 75 general-access microcomputers; photocopies; and calculators.

The Lehigh libraries are fully automated. Since 1985, when the libraries implemented a Geac Integrated Library System, the traditional card catalog has been replaced with ASA, the on-line catalog, and an on-line circulation system. Acquisitions, cataloging, and serials functions are also automated.

As a service to the extended community of alumni and regional corporations, the libraries sponsor a fee-based information service for business, industry, and government. A Friends of the Libraries program has also been in existence since 1981. The Friends programs provide another vehicle for university cultural activities in the forms of lectures, concerts, and exhibits.

The libraries are open 108 hours per week and, during the academic year, are open from 8 a.m. to midnight, Monday through Saturday, and noon to midnight on Sunday.

Media Center

University media services are represented by three modules. The Fairchild-Martindale Media Center provides opportunities for individual and group listening and viewing of audio and video tapes, cassettes, records, slides, and films, in a collection numbering more than 15,000 units. In addition, selected computer software is available for loan or use by the university community. The center includes an electronic classroom and general-purpose access microcomputers.

Media production services, located in the Linderman Library, offers a full spectrum of activities, including video and audio production; photographic services; slide preparation; and graphics. Consulting is also available for preparation and handling of equipment.

Audiovisual services prepares identification cards, handles the equipment needs for public affairs, and serves selected instructional needs for equipment.

Networking

The university has an InteCom digital PBX system that provides integrated voice and data communication services throughout the campus. Each room in the student residence facilities is equipped with a telephone to be used for on-campus, local, and long-distance services.

Students who own microcomputers are able to use the university network services over the same phone line. Students who do not own microcomputers may use any of approximately 200 Zenith microcomputers distributed in sites across the campus. The system provides access to the Computing Center mainframe computers, the Integrated Library System, and other computers located on the campus.

Each member of the university faculty is equipped with a Zenith microcomputer, which will gradually increase the academic use of the network in the instructional process.

Students may purchase Zenith microcomputers at the university's Microcomputer Store. Students or prospective students who are considering the acquisition of other than a Zenith microcomputer should consult members of the Computing Center staff to insure compatibility with the university's network system.

Computing Center

With its distinguished heritage of teaching and research in engineering and science, Lehigh has made extensive use of computers for more than two decades. In response to the need for an independent organization to serve the diverse needs of the academic community, the Computing Center was formed in 1966. Today, the center serves existing needs while anticipating and preparing for the future requirements of its user community.

The Computing Center, located in the E.W. Fairchild-Martindale Library and Computing Center, serves as a laboratory for departmental courses and research in computer theory and applications, including developmental programs. It provides computer and computing services to all university departments and centers for finding solutions to instructional, research, and administrative problems.

The central computing facility houses a Control Data Corp. CYBER 180 model 850; a Digital Equipment Corp. DECSYSTEM-20, and two International Business Machines Corp. 4381 systems, one of which is used exclusively for administrative processing. The Computing Center also houses and operates a CYBER 180, model 810, for the Center for Chemical Process Modeling and Control.

The CYBER 180, model 850, is equipped with 4 megawords (64 bits per word) of central memory, 4.3 gigabytes of on-line disk storage, 130 asynchronous ports, two synchronous ports, two nine-track magnetic tape drives, one 2,000-line-per-minute printer, a CalComp 1012 plotter, and a Hewlett-Packard 7586B publication-quality plotter. The principal high-level programming languages available on the system are FORTRAN, COBOL, and Pascal. In addition, various

simulation packages, special-purpose languages, and applications packages are provided.

The DECSYSTEM-20, model 2065, is equipped with two megawords (36 bits per word) of main memory, 1.3 gigabytes of on-line disk storage, 88 asynchronous ports, two nine-track tape drives, one 240-lines-per-minute printer, and one 12-page-per-minute Talaris 1200 laser printer. The principal high-level programming languages available include FORTRAN, COBOL, Pascal, APL, and BASIC. A data-base management system (DBMS-20) is supported, as are utilities primarily oriented to interactive computing.

The administrative IBM 4381, model 11, is a 32-bit, virtual storage-based machine with eight megabytes of memory. The system is equipped with two nine-track tape drives, five gigabytes of disk storage, and one 1200-line-per-minute printer. COBOL is the primary high-level programming language available on the system.

The IBM 4381, model 13, is part of a joint development project with IBM and is aimed at adapting the system to the networking needs of the campus. The system is a 32-bit, virtual storage-based machine with 16 megabytes of memory, 10 gigabytes of disk storage, 200 asynchronous ports, two cartridge tape drives, a 1200-line-per-minute printer, and a 20-side-per-minute double-sided laser printer.

In addition to these systems, the Computer Center maintains approximately 200 Zenith microcomputers that are located in sites across the campus. The center operates three microcomputer classrooms, each equipped with approximately 15 microcomputers and a large-screen projection system. In addition to the local area networks being installed at most sites, all of these microcomputers have the capability to connect to any other computer on campus by means of the InteCom communications system.

Research Activities

To preserve its role of impartial support for all users, the center does not engage in primary research. It has, on occasion, conducted research-related activities on its own or in cooperation with academic departments and research centers. However, approximately one-quarter of its computer utilization is devoted to supporting the computing activities of the research community.

In the past, research activity using the computer has been associated largely with the College of Engineering and Applied Sciences. Recently, however, use of the computer has expanded because of increased application of computers to disciplines in the College of Business and Economics, the College of Arts and Science, and the College of Education. Research centers and departments including the Sherman Fairchild Laboratory for Solid-State Studies, the department of mechanical engineering and mechanics, the department of industrial engineering, and the department of physics find computers helpful in the collection and analysis of laboratory and survey data, and in modeling using this data. With the advent of networking technology, communications between the center and other areas of the campus will increase dramatically.

Educational Opportunities

Seminars on various topics related to data processing in computing are held or sponsored by the center for faculty, staff, and students. Students desiring a more intensive educational experience in an operating environment may apply for part-time jobs in programming, user services, and operations. The center works closely with the Computer Society to meet the more independent inquiry needs of undergraduates. The society's adviser is a member of the center staff.

The center offers educational opportunities in the use of computers by providing computing resources for the academic community. More than one-third of the center's activity is devoted to instructional computing. Most jobs processed by the center are submitted by students as part of their normal academic coursework. The growth of interactive processing facilities benefits these users.

Art Galleries and Collections

The Lehigh University Art Galleries maintain and develop the university's permanent art collection, as well as present temporary exhibitions designed to make visual literacy a result of the university learning experience. More than twenty exhibitions a year in three campus galleries introduce students and the community to current topics in art, architecture, history, science, and technology. The exhibition schedule is supplemented by lectures, films, workshops, and opportunities for research in the permanent collection. Through exhibitions and programs, the art galleries play an important role in the educational mission of the university.

The art galleries occupy exhibition, storage, office and workshop space in several campus locations. The Ralph L. Wilson and Hall galleries are located in the Alumni Memorial Building; Maginnes Hall houses the DuBois Gallery and most of the painting collection; and the office and workshop are in Chandler-Ullmann Hall. A study gallery for prints, drawings, and photography is located at 616 Brodhead Ave. In addition, environmental sculpture is in place on both the South Mountain and Murray H. Goodman campuses. Professional museum standards are met in the care of the permanent collection and in the design and installation of exhibitions.

Exhibitions

Exhibitions and gallery events are planned to supplement formal classroom study in the visual arts, to create educational opportunities for the entire student body, and to enrich the cultural life of the campus and the community at large. The annual schedule includes the exhibition of works from the permanent collection, the use of borrowed objects, and the rental of traveling exhibitions from major museums and cultural institutions. Experts in various fields serve as guest curators of special project exhibitions. In addition, interdepartmental projects within the university lead to increased involvement by faculty and students. Undergraduates may take advantage of courses in museum studies as well as independent study in the collection.

Collections

Lehigh University's permanent art collection is a working and study collection intended as a resource for students pursuing formal study in the visual arts or museum studies, for the faculty, and for interested members of the community. Each year, several exhibitions are prepared from the collection. Individual works from the collection have recently been loaned to major museums throughout the nation.

The permanent art collection consists of a variety of works by old masters and contemporary artists. Important collection groups include: the Marion B. Grace Collection of European Paintings (Gainsborough, Reynolds, Goya, Hobbema, Hoppner, and others); the Dreyfus Collection of French Paintings (Bonnard, Sisley, Vuillard, Courbet); the Ralph L. Wilson Collection of American Art (paintings by Prendergast, Sloan, Henri, Lawson, Bellows, Davies, Burchfield; prints by Whistler, Hassam, Motherwell, Johns, Rauschenberg, Calder, Warhol); the Prasse Collection of Prints (Delacroix, Matisse, Renoir, Kent, Kunyoshi, Rivera); the Philip and Muriel Berman Collection of Japanese Prints (Hiroshige, Hokusai, Munakata, Utamaro) and the Philip and Muriel Berman Collection of Contemporary Sculpture.

Also, the Fearnside Collection of European Old Master Prints and Drawings; the Baker Collection of Chinese Porcelains; the Langermann Collection of Pre-Columbian Sculpture; the Mr. and Mrs. Franklin H. Williams African Collection (gold weights of the Akam and West African objects); the Lehigh University Photography Collection (Bravo, Hine, Weston, Porter, Rothstein, Harvan, Rau, Stoumen, Arbus, Bourke-White, Brassai, Fink, Callahan, Edgerton, Cameron, Abbott, Sander, Winogrand); and the Lehigh University Contemporary Prints Collection (Bearden, Rivers, Anusziewicz, Soto, Roth, Chryssa, Ruscha, Tobey, Calder, Kitaj, Marca-Relli, Genoves).

Lehigh University Press

In July 1985, Lehigh University entered into an agreement with the Associated University Press group to publish scholarly books under the imprint of the Lehigh University Press.

The foundation of the press represents a clear expression of faculty and institutional commitment to the advancement of scholarship. Nicholas Adams, chairman of the department of art and architecture, was named director and members of the faculty of the three undergraduate colleges serve on its editorial board.

Although the press will publish fine scholarship in all disciplines and fields, special emphasis has been given to areas with traditional strength at Lehigh: science, technology and society studies; economics and business studies; 18th Century studies. It is also hoped that the press can attract manuscripts that deal with eastern Pennsylvania and the Lehigh Valley.

The university press will bring Lehigh's name to the attention of the world of scholarship in a new way. Linking the name of the university to a list of fine work by scholars throughout the country can, in time, help reinforce the academic environment for faculty, graduate students, and undergraduates. In the future Lehigh's alumni will be able to maintain intellectual contact with the university through its press. The first publications from the press are expected to appear in fall 1987.

For more information, contact R. Nicholas Adams, Chandler-Ullmann Hall, Lehigh University, Bethlehem, Pa. 18015.

Resources for Students

Lehigh's administrators firmly believe that the interrelationship between students' classroom and nonclassroom activities can be fostered to become an educational avenue through which students grow, accept responsibility, and gain maturity in ways that will contribute to productive and meaningful lives. Through various services, students are assisted in becoming informed decision makers. They are also encouraged to develop greater self-awareness and self-confidence in their ability to lead the lives they choose.

General counseling of individual students often begins in the residential setting. Staff members in the residence halls include two live-in professionals, eleven graduate students who are hall directors, and approximately eighty undergraduate residence hall counselors, known as Gryphons. All staff members are carefully selected, extensively trained, and are available to assist resident students who may have a variety of concerns.

Students are also encouraged to seek counsel and guidance from professionals in many areas of student life. The office of the dean of students serves as a central agency to help students who have questions about academic and procedural matters, personal problems, legal problems, and other general concerns, both through its staff and through referral to other student affairs and academic offices.

Students who need assistance with their physical well-being are referred to the university health center.

If a student is uncertain about or needs to know more about his or her own capacities, interests, or personal characteristics, the university counseling service as well as testing services are available without charge. Confidential interviews may be arranged by any student who wishes to review his or her own progress and further evaluate or refine his or her thinking about future goals.

The university chaplain is available for the student with religious, moral, or personal concerns that are interfering with peace of mind and studies. A Roman Catholic chaplain also is in residence and available for counseling. A member of the faculty serves as adviser to Hillel Foundation members, who also may obtain spiritual advice from a local rabbi.

The office of career planning and placement services offers assistance to students in identifying and developing career options that can be initiated at graduation. The office also manages an active on-campus interviewing program for graduating students.

The registrar assists students who have questions involving matters of transferred credits, graduation requirements, and allied topics.

The office of financial aid consults with students who have financial concerns that are affecting their educational plans.

The Learning Center offers assistance for students whose study habits or reading skills may be impeding their academic success.

Many members of the teaching faculty are also deeply interested in students and student life. They contribute their services as academic advisers, activity sponsors, group sponsors and advisers, and in friendly personal relationships with students.

In these and in other ways Lehigh University endeavors to maintain the close contacts with students that characterize the smaller institution. Services are available for all student concerns, and the student need only turn to his or her nearest residence hall counselor, professor, or the *Lehigh Handbook* to learn where help can be obtained.

Health Center

The university offers health services to all students, undergraduate and graduate, full and part-time, resident, and commuting students. Medical care is available to staff and faculty on a fee-for-service basis.

The Health Center is located in Johnson Hall. The clinic hours in the fall and spring semesters are 9 A.M. to 6 P.M., Monday through Friday, and 9:30 A.M. to noon on Saturday. During vacation periods and summer, hours are 8:30 A.M. to noon, and 1 P.M. to 5 P.M. Monday through Friday; there are no Saturday clinic hours in the summer.

The outpatient department includes the medical clinic, minor surgical clinic, allergy clinic, and gynecological service. The emergency room, staffed by registered nurses with physcians on call, is open twenty-four hours daily during the academic year.

Inpatient care is available in the hospital unit for all students eligible to use the health center facilities. Registered nurses are in attendance with a physician on call at all times. No major surgery is performed at the Health Center. Critically ill individuals are usually transferred to a general hospital.

When medically indicated, referrals are made to the physical therapy service, which is supervised by a registered therapist and located as part of the health services suite. If a student is injured while engaged in any sport he or she must report as soon as possible to the Health Center.

Routine clinical studies are done in the Health Center laboratory from 8:30 A.M. to 2:30 P.M.

Prior to arrival to campus, each new or transfer student must submit to the Health Center a record of physical examination filled in and signed by a physician, and a completed health history form.

Following enrollment, additional examinations are provided by the Health Center for students participating in intercollegiate athletic programs, and when required for graduate school or scholarship programs. The Health Center does not provide examinations for military, insurance or employment purposes.

There is no charge for most of the care provided to students, whether inpatient or outpatient. Some exceptions are as follows: referrals to physicians, hospitals, or other medical facilities outside the student Health Center, and medications not carried by the Health Center and for which prescriptions need to be given. Staff, faculty, and other nonstudents are charged a fee-for-service.

A relatively low-cost university-sponsored insurance plan is available. Expenses covered include costs for several services that are not available at the Health Center, such as X-rays, certain laboratory studies, consultant fees, and medications not stocked by the Center. Hospital expenses are also covered. Students are urged to check with their parents regarding existing insurance coverage and to consider purchasing the

university-sponsored plan if they are not adequately covered.

A health service brochure is distributed to all entering freshmen and is available through the Health Center to all other students. This brochure describes in more detail the policies and program of health service.

Counseling Service

The counseling service, located in Johnson Hall, offers the opportunity for consultation with clinical and counseling psychologists in regard to a wide variety of concerns. The service is dedicated to the notion that college years should be productive, rewarding and satisfying ones during which students can grow in meaningful ways. Accordingly, counseling is designed to help students increase their self-understanding so that they can make better and more satisfying use of their intellectual and personal resources.

Counseling may involve discussion and exploration in regard to any concerns, feelings or problems that students might have, ranging from those that arise during the course of normal development to more serious emotional disturbances that might interfere with their adjustment to the university. When students are generally confused, insecure and unable to plan for the future with confidence, they can undertake counseling in psychological, career or academic areas. The purpose of counseling is to help them to gain insight into themselves and thereby become more fully aware of who they are and what they want to do with their lives.

Psychological testing is available as an important part of the counseling process and can provide pertinent and objective information about students' personal-social adjustment, career outlook and academic performance. Interpretation of test results is intended to help students achieve greater effectiveness in any or all of the areas mentioned.

Career testing in particular is offered to help students objectively evaluate their abilities, interests and personal values, which can be used as a basis for selecting personally satisfying educational and career goals. After an individual interview to discuss their scores, students are provided with copies of their results for continued reference.

The counseling service maintains a career information library as an important supplement to career testing. Students can refer to the library as they attempt to develop a clear idea of the educational and career worlds and how they fit into them. Accurate, current and thorough educational and career information enables students to select those directions appropriate to their own particular needs.

Specialized services offered include test-anxiety desensitization, personal and social anxiety reduction and meditative relaxation. Training in these self-management techniques may be undertaken separately or in conjunction with psychological counseling.

National testing programs required for graduate and professional school admission are administered for those students seeking to continue their education. The most frequently administered of these programs are the Graduate Record Examination, Law School Admission Test, Graduate Management Admission Test, and the Miller Analogies Test. Information is available to help students apply to and prepare for the various examinations.

Confidentiality is an important aspect of all the services that are offered. Interviews and test results are strictly confidential and records are not generally available to anyone outside of our office. Under exceptional circumstances, information is communicated to other university staff or faculty, or to parents, when students give their consent to do so, or when the well-being of the student or the welfare of the university might be in question.

All services are available without cost.

The Learning Center

Success at Lehigh depends in part on mastery of a number of advanced academic skills. Such skills are needed to study effectively (prepare assignments, take notes, outline, listen, recall information), to take examinations, to write well, to understand advanced mathematical concepts, and to keep up with a great deal of critical and comprehensive reading.

At Lehigh, a campus noted for its highly motivated student body and strenuous academic program, 15 percent of undergraduates, including a third of full-time freshmen, use the tutorial services of The Learning Center. Established in 1977, it provides a schedule of workshops, review sessions, and most importantly, individual tutorials in study skills, mathematics, physics, chemistry, computer science, reading and writing. Through a program of faculty and student referrals, along with periodic notices to the student body, the center helps students to improve specific communication and mathematical skills, to maintain acceptable performance levels, and to raise their academic standing. Individualized assistance is emphasized.

The Learning Center provides university students with a continuing opportunity for academic improvement through personalized instruction by professors, graduate teaching assistants, and a technical staff, and through a program of services that includes a language learning laboratory and a variety of audio-visual materials. The center is located in the studio at the top of Coppee Hall.

Career Planning and Placement Services

One function of a college education is to foster the growth and development of the student in preparation for a meaningful and satisfying life after college. Because developing one's career potential is an integral part of this process, Lehigh provides career planning and placement services for its students.

Career planning can best be described as an educational process through which students (1) identify and develop their abilities, aptitudes, and interests; (2) learn the relationship between their capabilities and interests, their university experiences, and professional opportunities outside the university; and (3) prepare for those opportunities.

Placement is the process of researching specific organizations that provide the types of work desired, interviewing for specific jobs through which career or professional interests can be satisfied, and then selecting from the options available the one that best meets students' needs. This part of the process also requires students to develop skills in such areas as writing effective resumes and cover letters, interviewing techniques, and individual job-search strategies to enhance productive interactions with employers.

The office of career planning and placement services offers the following resources and services to help students prepare for professional opportunities after graduation.

Career resources. Among the resources available in the career library are books and articles on career planning, current information on career opportunities, graduate school catalogs, job-search directories, a library of employer literature for approximately 400 companies, and a video-tape library covering a wide range of career-related subjects.

Career programs and workshops. The staff conducts a variety of seminars and presentations in collaboration with academic departments, professional societies, living groups, and other interested campus organizations. Workshops on resume writing, interviewing techniques, and job-search strategies are also offered.

Individual consultation. Students may meet with members of the staff to discuss their career options and goals, individual job-search strategies, effective interviewing, and related interests.

Placement manual. This manual helps students learn how to use the on-campus interviewing system, prepare for interviews and plant/office visits, write resumes and letters, and develop individual strategies.

On-campus interviewing. Staff members work with approximately 800 business, industrial, and government representatives who interview on campus each year. Seniors and graduate students typically take a total of about 8,000 interviews.

The goals of this integrated career planning and placement process are for Lehigh students to think of themselves as educated people with skills and abilities that have value to employers, and to think in terms of functional responsibilities rather than merely linking their major subjects to jobs, to acquire and develop the skills necessary to become self-reliant and informed decision-makers, to prepare for a competitive job market, and to develop their potential of becoming self-reliant managers of their own careers.

The office, located in Christmas-Saucon Hall, is open throughout the year.

Challenge For Success Program

The Challenge For Success Program (CFS) is a comprehensive supportive services program designed to enhance the recruitment and retention of the minority student community. Recruitment, retention, and relationships with industry are the primary components of the program.

The CFS program director works closely with the office of admission in the area of recruitment. Retention is enhanced by a six-week summer pre-freshman program, a student orientation, counseling for social and academic adjustment, a comprehensive tutorial service, and monitoring of academic progress.

The CFS Parent Committee and Black Alumni Council also assist in the retention effort. Relationships with industry include career awareness programs, summer employment, and a Corporate Advisory Board. The CFS Program is funded through gifts by corporate friends.

The CFS office is in Packer Hall, university center. In addition to the director, a graduate assistant, student assistants, and a staff of tutors are employed through the program. Tutorial services and the summer pre-freshman program are open to all students.

International Programs

To serve the unique needs of Lehigh's foreign students, scholars, and members of the faculty, the office of international programs helps approximately 570 international students, scholars, and faculty.

Foreign students are assisted in their adjustment to the United States. Activities also include programs that enhance American students' appreciation for the many cultures represented at Lehigh. These include trips, a discussion series, an international festival, individual advisement for foreign students, and an international student orientation each semester.

The office assists with issuance of immigration forms and documents and offers advice concerning immigration laws and regulations that affect foreign students.

The office of international programs is located in the University Center.

"Chemical Laboratory—Flickinger 1905." Largely unchanged, this is now Chandler-Ullmann Hall and home of the departments of psychology and art and architecture, the university Art Galleries, and the Marine Geotechnical Laboratory, among others.

III.

Academic Programs in the Colleges

From its beginnings in 1865, the university's educational goal has been simple. As university president Dr. Peter Likins has observed, Lehigh affords "a liberal education for a useful life." Broadly, the university seeks to instill general life skills necessary to successful functioning in any career. These include:

- good oral and written communication skills;
- analytical and problem-solving abilities;
- interpersonal skills;
- "technological literacy"—the ability to integrate humanistic, social, and cultural values with technological utility.

This educational philosophy, supported by the three undergraduate colleges in the university, includes not only classroom offerings spanning the theoretical to the applied, but also extracurricular opportunities and support systems that enrich and reinforce intellectual and human growth.

Students are expected to take responsibility for their education, to seek out the varied educational opportunities at the university, and to use them fully. Help is available in each of the colleges, as well as through general university offices.

Graduation Requirements

Students are expected to maintain regular progress toward the baccalaureate degree by carrying the "normal" course load—between fourteen and eighteen credit hours each semester. They may, however, wish to accelerate the pace toward graduation by using advanced placement credits, summer session study, course overloads during the regular semesters, and receiving credit for courses through examination.

Students in good academic standing earn their degrees by meeting the requirements of their specific degree curriculum as well as general university requirements. Waiver of program requirements is accomplished by a petition supported by the department and the committee on standing of students. Students should confer with their advisers on matters related to curriculum.

Students are expected to satisfy the credit-hour requirements of their chosen curriculum. Basic military science or aerospace studies credit hours are in addition to the credit hours specified in the curricula. A maximum of six credit hours of advanced military science and aerospace studies courses may be applied toward the baccalaureate degree.

Advisement

Every undergraduate is assigned a faculty adviser. Until the major is declared, help is also available through the dean's office of the college in which the student is enrolled. When the major has been chosen, a faculty member from the major department will act as the academic adviser.

This adviser is one of the most valuable resources in the educational process, not only to assist in making academic selections to match the student's particular background, interests, and future objectives, but also to identify program options, to work out an academic pace, and to develop career planning strategies. The adviser will help to identify other resources and support systems available at the university, such as The Learning Center, the counseling service and the office of career planning and placement services.

Special Academic Opportunities

The academic programs in the colleges are supplemented by five-year, two-degree programs as well as opportunities for advanced, foreign, and experiential study.

Five-Year, Two-Bachelor-Degree Programs

The university's five-year, two-degree programs enable a student to receive two bachelor degrees upon completion of five years of study.

The civil engineering and geological sciences program that affords two bachelor degrees, and the electrical engineering and engineering physics two-degree program are examples of programs in the College of Engineering and Applied Science.

Students who wish to declare a second major in another college or both a B.A. and a B.S. degree within the College of Arts and Science must have a minimum of thirty additional credit hours beyond the first degree credit-hour requirements in order to qualify for the second degree.

Most five-year, two-degree programs appear in the description of courses under Arts-Engineering and Five-Year Programs in Section V. It is possible to arrange for a dual bachelor degree program even after studying at Lehigh for some time. Engineering students, for example, who decide at any stage of study that they wish to meet the requirements for both the bachelor of arts and bachelor of science degree may complete the combined requirements in five years if the decision is made before the third year.

Arts-Engineering Option

The curriculum in Arts-Engineering is especially designed for students wanting a regular professional education in a field of engineering and also the opportunity to study broadly in a second field.

Arts-engineers fulfill all requirements for the professional engineering degree for which they are working. However, the first three years of science and engineering courses are scheduled over four years for the arts-engineer. During this period the arts-engineer is a student in the College of Arts and Science pursuing a bachelor of arts or bachelor of science major program.

In normal circumstances the student will complete work for a degree in the College of Arts and Science at the end of four years. The student transfers for the fifth year to the appropriate department of engineering, where he or she pursues a regular fourth year of science and engineering course work in the chosen field of engineering.

These arrangements make it difficult for an arts-engineer to qualify for the bachelor of science degree in the College of Engineering and Applied Science before meeting all requirements for the baccalaureate in the College of Arts and Science. In some instances it may be advisable to take the two degrees at the end of the fifth year. To qualify for both degrees, a student must submit for the second degree thirty credit hours in addition to the number required for the bachelor of science in engineering alone.

Arts-engineers working for the bachelor of arts automatically fulfill the engineering General Studies requirements of the College of Engineering and Applied Science while fulfilling the distribution requirements of the College of Arts and Science. Arts-engineers working towards the bachelor of science in biology, computer science, environmental science and resource management, geological sciences, geophysics, molecular biology, and statistics are advised to pay special attention to the engineering General Studies requirements, which must be met in time for the student to qualify for the B.S. in engineering.

Arts-engineers have the same opportunities for multiple majors and special interdisciplinary majors as are available to students working for the baccalaureate (B.S. or B.A. degree only) in the colleges.

Bachelor/Master Degree Programs

Of increasing interest to undergraduates are the two-degree, programs that may lead to both a bachelor and a master's degree in five years. Because Lehigh's well-established graduate programs are closely integrated with the undergraduate programs, it is possible to consider programs leading to the arts/master of business administration degree and the engineering/master of science in materials degree, among others. The fifth-year program in the School of Education enables those receiving a B.A. degree to accomplish professional teacher training and serve as salaried interns in public schools. After the completion of one year of full-time teaching, secondary teachers can receive the master of arts and elementary teachers can receive master of education degrees.

Many other five-year, graduate-level combination programs exist, and students are advised to consult with their adviser in planning such programs.

Arts/M.B.A. Program

Students in the College of Arts and Science may enroll in a special arts/master of business administration program by completing the 43 credit hours of courses listed below in the suggested sequence, while completing their major in one of the B.A. programs in the college during their first four years. At the end of this period, if they are admitted to the Graduate School, they may be granted their M.B.A. degree upon completion of an additional 39 hours of course work. This can usually be accomplished in two regular semesters and two summer sessions.

All courses listed below under "other required courses" must have a grade of B minus or better in order to be credited toward the M.B.A. program.

The following comprise the required courses during the four years in the college:

required background courses

*	Eco 1	Economics (4)
*	Math 41	BMSS Calculus (3) **and**
*	Math 44	BMSS Calculus II (3) **or**
*	Math 21	Analytical Geometry & Calculus (4) **and**
*	Math 22	Analytical Geometry and Calculus II (4)
**	Acctg 111	Management Information Systems in Business (3)

other required courses

**	Eco 145	Statistical Methods (3) **or**
**	Math 231	Probability and Statistics (3)

**	Acctg 51	Essentials of Accounting (3)
**	Acctg 52	Essentials of Accounting (3)
**	Eco 105	Microeconomic Analysis (3)
**	Eco 119	Macroeconomic Analysis (3)
***	Acctg 324	Cost Accounting (3)
***	Mgt 269	Management in Operations in Organizations (3)
***	Mgt 302	Quantitative Models—Conceptual (3)
***	Law 201	Legal Environment of Business (3)
***	Eco 229	Money and Banking (3)

* recommended in the freshman year
** recommended in the sophomore year
*** junior standing required for this course

Note: Students who do not take Acctg 52 and Acctg 324 as undergraduates will be required to take Acctg 413 as part of their M.B.A. course work.

Interdisciplinary Programs

The university's interdisciplinary programs are designed to cross the boundaries between colleges to accommodate new and developing fields as well as the interests of students. They include such programs as the following:

Afro-American Studies. A number of courses relevant to Afro-American Studies are available, such as: Engl 319, The Black in American Literature; Govt 352, Civil Rights; and Hist 131, The Black Experience in America; SR 368. Students interested in work in Afro-American Studies may work out an interdisciplinary program with their advisers and college deans.

Law and Legal Institutions. This minor program involves eighteen credit hours of course work in the College of Arts and Science and the College of Business and Economics and is available to students enrolled in all three colleges.

Freshman Seminars. Interdisciplinary, problem-centered, three-credit-hour seminars for freshmen enrolled in all curricula are called Freshman Seminars. These serve as a General Studies option in the engineering and physical sciences curriculum, a preliminary distribution elective in the arts and science curriculum, and an arts option or free elective in the business and economics curriculum.

Science, Technology and Society Program (STS). Faculty from all three colleges explore the interrelationships between science and technological advancement and the quality of human life in the popular STS program.

Interdisciplinary Technology Courses. Several courses have been developed to make students better aware of an understanding of the role that science and technology play in society. They are intended primarily for non-science and non-technology students, but science and engineering majors may also take them. None of these courses may be used to satisfy distribution or general studies requirements. These courses are taught by faculty from the College of Arts and Science and the College of Engineering and Applied Science. Course numbers may vary by semester; consult STS Program or College Dean's offices for specific details.

Experiential Learning

The accommodation of student interest extends beyond regular departmental offerings. Hands-on experiences in learning enrich classroom instruction. Each of the three colleges offers a number of such experiences for their undergraduates. Among them:

The Philadelphia Urban Semester. Undergraduates in all fields of study can earn 16 Lehigh credit hours by spending a semester studying in the nation's fourth-largest metropolis. They live, work, and study with other students from two dozen other institutions, supervised by faculty of the Great Lakes Colleges Association. This consortium of such leading Midwestern institutions as DePauw, Kenyon, Oberlin, and Wooster is a recognized leader in providing extra-mural academic programs both here and abroad.

The curriculum consists of two four-credit seminars and an eight-credit internship. All students are enrolled in a core "Seminar on the City" which introduces them to the field of urban affairs and to Philadelphia. The second seminar is elected from a half-dozen more specialized urban topics; recent choices available have included "Folklore in Philadelphia," "Art in the City" (which met each week at a different site), and "Justice." Internships involve working four days weekly in a public or private placement which tests the student's aptitude in a variety of practical ways while enhancing appreciation of city life.

The Washington Semester. Opportunity is available each year for several juniors or seniors to spend a term studying in Washington, D.C., in cooperation with American University. Lehigh University is a member with 180 other colleges and universities.

Students enroll at Lehigh but spend the semester in residence at American University with the students from other participating colleges.

The curriculum consists of national-government seminars, an internship, and a written research project. Besides the national government program, the student may choose other program offerings such as urban semester, economic policy semester, journalism, public administration, foreign policy semester and justice semester.

Study in foreign countries. Study abroad is increasingly recognized as a valuable component of undergraduate and, in some cases, graduate programs. Students maintaining a B average (3.00 cumulative) or better are encouraged to consider enrolling in an acceptable program or as regular students in an institution in a foreign country.

In some cases, study programs may include professional internships with foreign firms or organizations. Such internships are monitored for academic value and students will be required to report on their experiences in detail.

Students must clear their study plans in advance with the departments concerned, the major adviser, the registrar and G. Mark Ellis, associate dean, College of Arts and Science. Students desirous of applying their financial aid to study abroad must consult with the office of financial aid prior to their departure. For foreign-language students, the approval of the adviser for the foreign language concerned is required.

Through the department of modern foreign languages and literature, the university offers scholarships for qualified students, on a competitive basis, to assist with travel costs for foreign-language programs.

As a member of the Lehigh Valley Association of Independent Colleges (LVAIC), Lehigh University sponsors three six-week summer programs in Europe: Poitiers, France; Bonn, Federal Republic of Germany; Seville, Spain. The six credits earned are automatically transferable to Lehigh University and will be counted as part of the student's cumulative grade-point average.

The Center for International Studies, Maginnes Hall, coordinates foreign study and internship applications and maintains listings of current programs. Students are encouraged to inform the center of their interest in foreign study or internship by completing an application form at the end of their freshman year or early in their sophomore year to allow adequate planning time.

The Exchange Program with British Universities. Lehigh University has formal exchange agreements with seven British universities. Students selected for the program can study at the University of Buckingham for a semester or at the following universities for a year: University of Edinburgh, University of Kent, London School of Economics and Political Science, University of Manchester Institute of Science and Technology, University College of London University, and University of York.

In this program, courses and grades are transferred and transcripted to Lehigh. Tuition is paid directly to Lehigh as if the student is still in residence and financial aid continues. Students are responsible for their individual board and lodging at rates comparable to those of Lehigh. Travel scholarships are available.

Applications are available through the dean's office in each college. Generally a 3.0 grade-point average is required. Students must obtain their adviser's approval and the endorsement of their college. All applicants are interviewed by the committee for study abroad, which selects candidates for the available positions.

Preparation for Graduate Work

Students planning to continue in graduate programs should take advantage of the flexibility in many undergraduate programs to design an upper-division curriculum that meets requirements in the anticipated graduate program.

The policy of the Graduate School provides as much flexibility as possible for students who wish to change to new but related fields of study after the baccalaureate degree. Students should consult with their previous program adviser and the department representative of the new field to establish an academic program that will remedy any deficiencies in background.

Curricular Flexibility

Choice is a regular part of university life, and encompasses the determination of a college and major, the selection of courses each term, and the development of life goals and career options.

Many of these choices are academic in nature. The undergraduate curricula are flexible, designed to accommodate the changing interests and needs of students. Boundaries between colleges are as fluid as possible to provide many options in an educational program. For instance, students may take a bachelor of science (B.S.) degree in the College of Business and Economics or the College of Engineering and Applied Science with a minor in journalism in the College of Arts and Science. There are five-year programs for which degrees are awarded in two colleges.

Transfers between undergraduate colleges is permitted but only *after the freshman year*. Students considering such a transfer must confer with their advisers to begin the process.

Academic offerings of the various departments are described in Section V. To provide additional flexibility and encourage student initiative and depth of investigation, the university has developed academic alternatives including the following:

Provisional Courses. Departments may introduce Provisional Courses temporarily within a semester, either experimentally or as a response to a contemporary social or scientific issue. If successful, a course may become part of the regular curriculum. Such courses, identified with a 97 or 98 number (preceded by a 1, 2, or 3 indicating level) may sometimes be taken on a pass/fail basis. They may not be developed in time to be included with course listings but they are incorporated into the registrar's semester roster for a maximum of two semesters.

Independent Study. Juniors and seniors of ability who wish to concentrate in their chosen field can substitute no more than four or six credit hours of independent, unscheduled work each semester for an equal number of credit hours of elective work required for graduation. Students, in collaboration with the major adviser, with the advice of the departmental chairperson and consent of the college dean, may structure such a project for study in any curriculum and most major study sequences.

Pass/Fail Option. Students have the opportunity to study in areas without concern for possible poor grades by electing a pass/fail option. Intended for exploration outside the major field, this option is open to those who are sophomores and above, in good standing, who have declared a major. The pass/fail option may not be used for major or minor subject credit toward graduation. Consultation with the adviser is suggested.

Graduate Courses. Qualified undergraduates may petition the Graduate Committee to register for 400-level courses if they are certified by the course instructor and the department chairperson concerned.

Cooperative College Program. Students can attend courses and programs offered by the member institutions of the Lehigh Valley Association of Independent Colleges (LVAIC). The other institutions are Allentown College of St. Francis de Sales, Cedar Crest College, Lafayette College, Moravian College, and Muhlenberg College. Consult the registrar for details.

Summer Study. Remedial and advanced academic work can be taken in two summer sessions. Special programs and field work opportunities are available for intense in-depth experience. There are also short courses in a variety of subjects. A listing of planned summer programs is available in the spring.

Honors Opportunities

Each department offers honors work adapted to its curriculum for students who wish to demonstrate unusual academic ability and interest in exploring a chosen field through independent study and research. The precise nature of the program for each student is determined by the academic major department, but may include: unscheduled work or independent study; participation in graduate (400-level) courses; and an honors thesis or project.

Qualified candidates should inform their academic advisers by the end of the junior year of their intention to work for departmental honors. The adviser will give the college and the registrar names of seniors working for departmental honors in particular majors. Names of those students attaining departmental honors are published in the commencement program.

Undergraduates in the College of Arts and Science may apply for acceptance into the College Scholar Program, which offers unique opportunities for those qualified to develop their critical faculties and intellectual interests.

College of Arts and Science

John W. Hunt, *dean* (through June 30, 1987); G. Mark Ellis, *associate dean*; Steven S. Krawiec, *associate dean* (through August 15, 1987)

The College of Arts and Science offers several curricular options:

- A four-year curriculum in arts and science, leading to the degree of *bachelor of arts*;
- Four-year curricula in the fields of biology, computer science, environmental sciences and resource management, geological sciences, geophysics, molecular biology, and statistics, leading to the degree of *bachelor of science* in the designated field; and
- A *five-year curriculum* in arts-engineering leading to a bachelor's degree from the College of Arts and Science and a bachelor of science degree in the student's field from the College of Engineering and Applied Science.

Students in all of these curricula must complete Arts and Science 1, Choices and Decisions, and meet a requirement for freshman English. The normal requirement is Engl 1 and 2, 4, 6, 8 or 10. See Advanced Placement in Section II.

Specific requirements for many of the degree programs described in this section may be found in Section V.

Major Subjects

The college offers the following major subjects:

Bachelor of Arts Degree

Humanities: architecture; art; classics—classics and classical civilization; English; journalism—journalism and science writing; modern foreign languages—French, German and Spanish; music; philosophy; religion studies; theater.

Social Sciences: American studies; economics; foreign careers; government; history; international relations; social relations (includes anthropology, social psychology, and sociology); urban studies.

Mathematics and Natural Science: applied science; biology; chemistry; computer science; geology; mathematics; natural science; physics; predental science; premedical science; psychology.

Bachelor of Science Degree

Natural Sciences: biology; computer science; environmental sciences and resource management; geological science; geophysics; molecular biology; statistics.

(Note: On July 1, 1987, the departments of chemistry and physics will move from the engineering college to the College of Arts and Science, where they will join the other science departments. Because the change is primarily related to the university's organization, students enrolled in chemistry and physics programs will not be significantly affected in their course work.

Major Field of Concentration

By the end of the sophomore year, each student in the curriculum of arts and science selects some sequence of studies as a major field of concentration. A major consists of at least fifteen hours of advanced work in the field chosen. Including preliminary college work, the minimum number of hours constituting a major is 30.

The major field of concentration is designed to enable a student to master an area of knowledge so far as that is possible during the undergraduate years. In all fields, certain courses are prescribed, but merely passing courses will not satisfy the major requirements. A student must achieve a minimum 2.0 average in major courses.

Standard major sequences. The student may choose one of the standard major sequences. When a student selects one of these standard majors, the chairperson of the department offering the major or the director of a nondepartmental major becomes a student's major adviser and makes out the student's major program. The final responsibility for meeting both major and nonmajor requirements, however, rests with the student.

Special interdisciplinary majors. In addition to the standard major programs, specially structured interdisciplinary major sequences are possible.

For example, a student interested in a professional school of urban or regional planning might wish to structure a special major consisting primarily of courses in government and economics, or in economics and social relations.

Any student may, with the aid of faculty members chosen from the disciplines involved, work out an interdisciplinary major program to include not less than thirty hours of related course work, of which at least fifteen hours shall consist of advanced courses. The program must be approved by the major advisers and the dean of the college.

Multiple majors. Some students choose to fulfill the requirements of more than one major sequence. A student initiates this by having separate major programs made out by different major advisers.

Because successful completion of only one major program is required for a baccalaureate degree, a student with more than one program is asked to designate one as the administrative major for preregistration purposes but is expected to maintain normal progress in fulfilling the requirements in both.

Students who wish to declare a second major in another college or both a B.A. and B.S. degree within the college must have a minimum of thirty additional credit hours beyond the first degree credit-hour requirements in order to qualify for the second degree.

Junior-Year Writing Certification

The faculty of the College of Arts and Science is committed to the concept that writing is a valuable tool for learning and views the ability to write well as a valuable professional skill. Students are encouraged to take courses that require writing throughout their years in the college.

Beginning with the Class of 1988, each student in the college must complete at least one "writing-intensive" course and receive writing certification from the instructor. Students normally take this course during the junior year. Students must follow the guidelines for this requirement set up by their major departments. Some departments specify that the "writing-intensive" course must be in the major field; some departments require "writing-intensive" courses in specified disciplines other than the major; and, other departments allow their majors to choose freely from "writing-intensive" courses across the college. Courses that satisfy the junior-year writing requirement may also satisfy major or distribution requirements.

Bachelor of Arts Degree

The curriculum in arts and science emphasizes a liberal education. It asks the student, in collaboration with the adviser, to select courses to satisfy three general categories, namely, distribution to insure breadth of education, a major field of concentration to provide depth, and free electives to provide breadth and depth to meet the student's needs.

Distribution Requirements

There are three categories of requirements: a *College requirement* (Arts and Science 1, Choices and Decisions) designed to acquaint freshmen with the approach to a liberal education; a *General Skills* requirement, to be completed by the end of the sophomore year, ensuring minimum competency in English, a foreign language, and mathematics; and the *Distribution* requirement (to be completed by the end of the junior year), which obliges all bachelor of arts students, whatever their major, to take a minimum number of courses in five subject areas which are essential for a liberal-arts education.

I. **College Requirement** (to be completed by the end of the freshman year), one hour total

A&S 1, Choices and Decisions	1 credit hour

II. **General Skills Requirement** (to be completed by the end of the sophomore year), 18-22 hours total

A. *English composition* (two courses during the freshman year) — 6 hours

B. *Foreign language* (completion of, or credit for, second year level in any modern or classical language studied in high school; or two semesters at the elementary level of languages not offered for admission). — 6-8 hours

C. *Mathematical Sciences* (two courses) — 6-8 hours
Two courses from among mathematics, computer programming, logical theory (Philosophy 14 and 214 are acceptable), of which at least one must be a mathematics course.

III. **Distribution Requirement** (to be completed by the end of the junior year), total: 36-42 hours

At least one of the courses in Physical or Life Sciences must also include the associated laboratory course. Courses taken within the major department to satisfy a major may not satisfy distribution requirements in more than one area.

A. *Physical Sciences* — 6-10 hours
Two courses from among those designated in: astronomy, chemistry, geological sciences, physics.

B. *Life Sciences* — 3-4 hours
One course from among those designated in: biological anthropology, biology, and psychology.

C. *Social Sciences* — 12-13 hours
Four courses from among those designated in: anthropology, economics, government, history, international relations, journalism, psychology, social psychology, sociology, STS, and urban studies.

D. *Humanities* — 12 hours
Four courses from among those designated in: classics, history, history of architecture, history of art, history of music, history of psychology, history of theater, journalism, literature, cultural studies, music theory, philosophy, and religion studies.

E. *Performing and Studio Arts* — 3 hours
One course from among those designated in:

architectural design, creative writing, journalism, speech, theater, studio arts, music composition and performance.

Total required for graduation: 121 hours

A student's program, including the choice of distribution requirements, is not official until approved by the adviser.

Graduation Requirements

The bachelor of arts degree (B.A.) requires the completion of a minimum of 121 credit hours of collegiate work, apportioned to cover distribution and concentration requirements. A cumulative average of 2.0 or better in courses required in the student's major program and the completion of all general requirements apply to all candidates for baccalaureate degrees. Candidates must complete Arts and Science 1, and must receive writing certification in the junior year. A maximum of six credit hours of advanced military science or aerospace studies courses may be applied toward the degree.

Bachelor of Science Degree

Students desiring to major in the fields of biology, computer science, environmental sciences and resource management, geological sciences, geophysics, molecular biology, and statistics may elect to work for a bachelor of science degree (B.S.). This option is also open to arts-engineers desiring to major in one of these fields.

A student electing to work for the bachelor of science degree may have a strong preprofessional orientation and will take more courses in the major field of concentration than will another in the bachelor of arts (B.A.) program. In all other respects the student in a bachelor of science curriculum meets the same requirements as the student in the bachelor of arts program, except that the B.S. candidate is not asked to fulfill the same distribution requirements.

The bachelor of science distribution requirements in the College of Arts and Science consist of a minimum of thirty credit hours taken in courses outside the natural sciences and mathematics. Of these thirty credit hours, at least twelve credit hours must be taken in courses in the humanities, and at least twelve in the social sciences. The humanities and social science courses satisfying this distribution requirement are those approved by the faculty for this purpose and listed under the appropriate categories of the distribution requirements for the B.A. degree.

Graduation Requirements

The bachelor of science degree requires the completion of the minimum number of credit hours of collegiate work indicated for the curriculum, including the 30-credit-hour B.S. distribution requirement. Candidates must complete all general requirements for the baccalaureate degree, including completion of Arts and Science 1 and completion of junior-year writing certification. A maximum of six credit hours of advanced military science or aerospace studies courses may be applied toward the degree.

Language Requirements

Students who are planning on graduate study toward the doctor of philosophy degree are reminded that most graduate schools require Ph.D. candidates to demonstrate a reading knowledge of one or two foreign languages. Ability to use foreign languages is beneficial in many careers, such as law, journalism, commerce, industry, and government.

Centers and Institutes

The college also oversees research and scholarship in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Center for Advanced Technology for Large Structural Systems, Biotechnology Research Center, Center for the Application of Mathematics, Center for Environmental Studies, Center for Health Sciences, Center for Innovation Management Studies, Center for Social Research, Center for Surface and Coatings Research, Emulsion Polymers Institute, Energy Research Center, Institute for the Study of the High-Rise Habitat, Lawrence Henry Gipson Institute for Eighteenth-Century Studies, Lehigh Valley Center for Jewish Studies, Materials Research Center, The Stone Harbor Marine Laboratory, Technology Studies Resource Center.

Minor Programs in the College

Certain departments, divisions, and programs in the College of Arts and Science afford an opportunity to minor in an additional field of concentration other than the major field.

A minor consists of at least fifteen credit hours; the specific content is determined in the department, division, or program concerned. A minor is optional and, if successfully completed, will be shown on the university transcript in the same manner as the major field of concentration. A 2.0 minimum grade-point average is required for courses in the minor. Because of this requirement, no course in the minor program may be taken with Pass/Fail grading.

If a minor program is not listed under the department desired, the student should consult the department chairperson.

It is the responsibility of students desiring a minor to initiate it no later than the beginning of the junior year by filing a minor program with the department, division, or program where it is offered. The student's major adviser keeps appropriate records.

Minors in the College of Arts and Science departments and programs are available for degree candidates in other colleges within the university, with approval of their college adviser.

Education Minor

The education minor helps undergraduates explore a career option in school teaching or other professional careers with elementary, secondary, or special-education students. The minor may accelerate entry into a teaching career because appropriate credits from the minor may be applied toward completion of teacher-certification credits for those admitted to Lehigh's graduate-level Teacher Intern Program.

The minor offers a systematic background of professional education experiences, coordinating practicum activities with theory courses designed to provide a foundation for future educational studies. Its focus is exploratory. No career decision is required but the minor is provided for those with a serious interest in considering the teaching profession.

The experiences of the minor are intended to enrich an individual's understanding of education as a central intellectual phenomenon of our culture and to provide self-understanding of one's own potential as an educator.

An undergraduate may take one or all of these courses during the junior and senior years with the approval of the adviser. Completion of the minor does not assure admission to the Teacher Intern Program to become a certified professional. However, if the student passes the screening process on the basis of previous work and interviews, he or she may enter the intern program with advanced standing toward certification.

The program coordinator is Robert L. Leight, 524 Brodhead Avenue.

Fifteen credit hours are chosen from among the following courses for those in the education minor:

Educ 312	Classroom Practice (1) (must be taken concurrently with Educ 314)
Educ 314	Intern Seminar (2) (must be taken concurrently with Educ 312)
Educ 429	Child Development (3)
Educ 441	Youth in Society (3)
Educ 394	Special Topics in Instruction and Curriculum: Introduction to Foundations of Education (3)
	Elective Education course (appropriate to student's objective (3)

East Asian Studies

The minor program in East Asian Studies affords undergraduates in any college within Lehigh an opportunity to acquire a systematic knowledge of East Asia (China, Japan, Korea and the Pacific). The program encompasses the rich historical and cultural heritage of the countries of East Asia, as well as their growing importance in world affairs and their critical relationship to the national interests of the United States.

The minor is intended as a complement to a student's major field of study, and it is flexible according to individual needs. Students are free to survey the field broadly or concentrate in a special area such as the Chinese language. The minor is composed of any five courses (15 credits minimum) in East Asian studies, chosen from an approved list in consultation with the program director. Courses in Japanese language and other East Asian topics are offered at Lafayette College and may be taken for credit by Lehigh students. In addition, students are encouraged to avail themselves of a variety of extracurricular activities that are offered in East Asian studies, such as special lectures and seminars, films, performances and exhibits.

The over-all program is administered by the East Asian Studies Committee, an interdisciplinary body of faculty members with a special interest in the region. This committee oversees both the formal academic work within the program as well as the extracurricular activities sponsored at the university. It also cooperates with the East Asia Society, the Chinese Students Club, and other campus organizations involved in some aspect of East Asian studies.

The following courses are regularly offered in the program and new ones are currently under development in a number of other fields. It is expected that a major program in East Asian studies will be introduced shortly in cooperation with the Lehigh Valley Association of Independent Colleges. The director is Norman J. Girardot, Maginnes Hall.

East Asian Studies Courses

Anth 184	Cultures of the Pacific (3)
Chin 1	Elementary Chinese I (4)
Chin 2	Elementary Chinese II (4)
Chin 11	Intermediate Chinese I (3)
Chin 12	Intermediate Chinese II (3)
Engl 91	Special Topics in English (1-3)
Govt 106	Chinese Politics (3)
Govt 108	Japanese Politics (3)
Govt (IR) 322	Politics of Developing Nations (3)
IR 21	Modern East Asia (3)
IR 22	Contemporary East Asia (3)
IR 321	China in World Affairs (3)
MFL 71	Introduction to Chinese Culture (3)
Rel 115	Religions of China (3)
Rel 117	Religions of Japan (3)
Rel 226	Topics in Asian Religions (3)

Health and Human Development Minor

The minor in health and human development, located primarily within the College of Arts and Science, is an interdisciplinary program designed to provide insight into the social/scientific aspects of health issues through the human life cycle. While this minor program is open to anyone in the three undergraduate colleges, it may be of particular interest to students preparing for careers in medicine, dentistry, optometry, allied health professions, health administration, social work, and child or adult development.

The program is administered through the Program in Health and Human Development, an interdisciplinary group of faculty members who have research interests in this area. Current research studies cover all aspects of the life cycle, including the health dimensions of both normal and abnormal child development, reproductive health issues, adult life crises such as illness and loss, and dimensions of aging. Students are able to serve as research assistants in some of these studies. The program also sponsors a series of lectures and colloquia. Students in the minor program are encouraged to avail themselves of these opportunities.

The minor consists of a minimum of fifteen credit hours chosen in consultation with the program director, Nancy Fulford, health professions coordinator, Maginnes Hall. Students may decide to survey the field broadly or to concentrate in the area of health or human development.

required courses (6 credit hours)

Hist 8	History of Medicine in America (3) **or**
Soc 135	Medicine and Society (3)
and	
Psych 107	Child Development (3) **or**
Psych 108	Adolescent Development (3) **or**
Psyc/SPsy 109	Adult Development and Aging (3)

elective courses (9 credit hours) chosen from three different disciplines:

Anth 321	Anthropology of Physical and Mental Health (3)
Govt 306	Public Policy Process (3)
Hist 8	History of Medicine in America (3)
Hist 337	History of Medical Thought (3)
Hist 339	Topics in American Public Health (3)
Hist 340	Topics in American Medicine (3)
Phil 116	Medical Ethics (3)
Psyc 77	Drugs and Behavior (3)
Psyc 107	Child Development (3)
Psyc 108	Adolescent Development (3)
Psyc 109	Adulthood and Aging: Social and Psychological Perspectives (3)
Psyc 305	Abnormal Psychology (3)
Psyc 351	Cognitive Development in Childhood (3)
Psyc 361	Special Topics in Adult Development (3)
Psyc 363	Social and Personality Development (3)
SPsy 109	Adulthood and Aging: Social and Psychological Perspectives (3)
SPsy 321	Social Psychology of Developing Adults (3)
Soc 135	Medicine and Society (3)
Soc 327	Health Policy Analysis (3)
Soc 333	Sociology of Aging (3)
Soc 341	Women and Health (3)
SR 331	Social Perspectives on Death and Dying (3)

Interpersonal Behavior in Small Groups And Organizations

This minor has as its general focus the understanding of face-to-face interaction among human beings in small-group settings in a variety of organizational contexts. It will be relevant to students interested in personnel, the helping professions, group work, or any occupation requiring interpersonal skills in group settings.

The minor has both a cognitive and experiential learning dimension. Thus the student may become acquainted with the major theories, concepts, and issues concerning interpersonal behavior in social contexts and also with some of the tools, skills, and insights that promote growth and competence in social interaction. Experiential learning also includes training in techniques of naturalistic observation of social interaction in small groups and organizations.

These courses are not arranged in a sequence; that is, while they individually may put more stress on the cognitive or experiential dimension, none are prerequisites for any other. Thus students may select any course, subject to the prerequisites and requirements of the university and the department, as well as availability.

The coordinator is Robert E. Rosenwein, Price Hall.

Fifteen credit hours are chosen from among the following courses for the minor in Interpersonal Behavior:

Mgt 321	Organizational Behavior (laboratory sections only) (3)*
Psyc 121	Encountering Self and Others (3)

SR 118	Close Personal Relationships (3)
SPsy 121	Social Psychology of Small Groups (3)
Anth 151	Utopias and Alternative Communities (3)
SR 395	Methods in Observation (3)
SPsy 312	Interpersonal Behavior in Small Groups (3)

Jewish Studies

The Jewish Studies minor offers students of diverse backgrounds the opportunity to explore the history, literature, religion and social institutions of the Jewish people from its inception to the present. The diversity of courses highlights the interaction of Judaism with other world civilizations and the mutual influences between Judaism and societies and cultures of Europe, the Middle East, and the United States. Through the Jewish Studies minor, a student has the opportunity to study Judaism from the perspective of various academic disciplines.

The program is designed to be of interest to students with diverse interests and fields of concentration. The study of Jewish society and culture can enhance one's understanding of European or American society and culture. Students of psychology and sociology will find that Jewish Studies contributes to their understanding of such issues as prejudice and anti-Semitism, assimilation, and religious-cultural pluralism.

The study of Jewish religion and philosophy brings one face to face with such problems as God, religious faith and doubt, moral responsibility, evil and human suffering. In addition, studying Judaism in comparison with another religious tradition heightens one's understanding of both religions. The study of Judaism introduces the student of literature to a broad sample of diverse literary forms and themes from diverse periods and cultural settings.

The formal program of courses is augmented through a program of lectures, colloquia, films, and other cultural exhibits. Study abroad, particularly in Israel, is encouraged as a means to augment and broaden one's understanding of Jewish civilization. Under the sponsorship of the Lehigh Valley Center for Jewish Studies, students may study for a semester or a year at the Hebrew University in Jerusalem or Tel Aviv University. During the summer, students may earn up to six credit hours by participating in the Hebrew University summer study program in Jerusalem, the kibbutz-study program of the Hebrew University, or the Tel Miqne-Ekron archaeological excavation. For further information on programs in Israel, students should contact Myra Rosenhaus. Students should coordinate their minor program in Jewish Studies with the director of the center, Laurence J. Silberstein, Maginnes Hall.

A minimum of fifteen credit hours is to be selected from the following courses. (A maximum of six credit hours of Hebrew may be counted.)

Jewish Studies Courses

Engl 312	Jewish Literature (3)
US 328	The American Jewish Community (3)
Hebr 1	Elementary Modern Hebrew I (3)
Hebr 2	Elementary Modern Hebrew II (3)
Hebr 11	Intermediate Modern Hebrew I (3)
Hebr 12	Intermediate Modern Hebrew II (3)
IR 31	Middle East in World Affairs to 1945 (3)
IR 32	Middle East in World Affairs Since 1945 (3)
MFL 61	Cultural Mosaic of Modern Israel (3)
Phil 133	Medieval Philosophy (3)
Rel 73	Introduction to Jewish Studies (3)
Rel 108	Modern Judaism and the Search for Meaning (3)
Rel 111	The Hebrew Bible/Old Testament (3)
Rel 116	Zionism and the Renewal of Judaism (3)
Rel 127	Sex and Gender in Judaism: The Feminist Critique
Rel 141	Literature of the Holocaust (3)
Rel 145	Jewish Thought Since the Holocaust (3)
Rel 151	The Jewish-Christian Encounter (3)
RS/Hist 154	The Holocaust: History and Meaning (3)
Rel 163	Contemporary Theology (3)
Rel 244	Major Figures in Modern Jewish Thought (3)
Rel 257	Jewish Thought Since the Enlightenment (1750 to Present) (3)
Rel 298	Introduction to Rabbinic Literature (3)
Rel 371	Special Topics (1-3)

Latin American Studies

The minor in Latin American Studies represents an opportunity to explore the language, literature, history, cultures, and socioeconomic problems of our neighbors to the south. It provides a perspective on the problems of other underdeveloped regions of the world, in contrast to most offerings in the humanities and social sciences that usually focus on the mainstream of western culture, notably the United States and Western Europe.

It is worth noting the importance of Latin American cultures in the future of the hemisphere. Latin America is the most rapidly growing part of the world, and by the year 2000 it is predicted that the area will have a population of 600 million, or twice that of Anglo-America. Several countries, especially Brazil and Mexico, are undergoing rapid industrial expansion. Consequently, besides the personal values to be derived from this curriculum, there are business, governmental, and related career possibilities.

The minor program represents fifteen credit hours, or five courses, chosen from economics, history, sociology and Spanish or Portuguese in discussion with the coordinator, James S. Saeger, history department, Maginnes Hall.

Required course (3 hours)

Span 152	Cultural Evolution of Latin America (3)

Elective courses (12 hours) chosen from:

MFL 81	Brazil and its Culture (3)
Eco 305	The Economic Development of Latin America (3)
Hist 49-50	History of Latin America (3)
Hist 265	Mexico and the Caribbean (3)
Hist 266	Argentina, Brazil and Chile (3)
Hist 368	Seminar in Latin American History (3)

courses in Latin American literature (6)

No more than six credit hours should be chosen from a given department. A proficiency level in Spanish and/or Portuguese is required, depending on the student's area of special interest.

Law and Legal Institutions

This program, based in the College of Arts and Science, is designed to foster interdisciplinary cooperation with the faculties of the other colleges in the university. The Law and Legal Institutions minor program is open to students from all three undergraduate colleges. Although the program may be of particular interest to some pre-law students, it should not be viewed as the preferred pattern for those hoping to attend law school.

The eighteen-credit-hour program stresses the systematic analysis of contemporary legal institutions, coupled with an examination of their historical antecedents, especially those in the Anglo-American common-law tradition. The program also exposes students to both public and private law, and to courses using the traditional case methods as well as those of the social sciences and philosophy.

Each student's minor program is a coherent combination of courses individually and jointly designed by the student and the program director. To avoid unnecessary confusion, students are urged to declare their minor in Law and Legal Institutions by the end of their sophomore year, in no event later than the last semester of their junior year.

Required preliminary courses (6 credit hours)

Phil 13	Practical Logic (3)
Law 11	Introduction to Law (3)

Elective courses (nine credit hours required with at least one course in each category. Law 201 may not be included in the minor programs of students in the College of Business and Economics.)

Category I—Case Method

Govt 351	Constitutional Law (3)
Govt 352	Civil Rights (3)
Govt 354	Administrative Law (3)
Jour 122	Law of the Press II (3)
Law 201	Legal Environment of Business (3)
Phil 221 (Law 221)	Sex Discrimination and the Law (3)

Category II—Non-Case Method

Clss 161	Roman Law (3)
Hist 260	American Constitutional and Legal History (3)
Hist 357	English Constitutional and Legal History to 1783 (3)
IR 361	International Law (3)
IR 362	Seminar in International Law (3)
Phil 122	Philosophy of Law (3)

required advanced course

Legal Research Special Topics (3)

This course is taken during the senior year. It aims at developing basic legal research skills and at using at least some of these skills in the execution of a research project focused upon an area of law that is of interest to the student. These projects are approved and supervised by a faculty member affiliated with the program and receive course credit in that faculty member's department.

For further information, consult the program director, J. Ralph Lindgren, philosophy department.

Russian Studies

The minor in Russian Studies is an interdisciplinary program designed to provide a broad range of study of Russian and the Soviet Union. It can be considered the beginning of a specialization in the area that can be continued in graduate school, or a useful area of concentration for certain careers after graduation (e.g., foreign service, governmental employment, business, foreign trade, etc.). The program may also be of general interest to nonspecialist students who wish merely to do focused work on the culture and society of the major country in the socialist world.

The minor in Russian Studies requires eighteen credit hours of formal course work, chosen in consultation with the program director, Donald D. Barry, department of government.

required courses (15 hours)

six hours of college-level Russian based on the student's level of competence; **or**

six hours of Russian literature in translation (6)

Govt 161	The Soviet Political System (3)
Hist 261	A History of Russia to 1855 (3) **or**
Hist 262	A History of Russia, 1855 to Present (3)
IR 133	Diplomacy of Russia to 1945 (3) **or**
IR 134	Diplomacy of Russia Since 1945 (3)

elective course (3 credit hours); one course from the following:

any other Russian-language course (3)

any other Russian literature course (3)

Govt 318	Communist Political Systems (3)
Eco 309	Comparative Economic Systems (3)
Hist 261 or 262	(whichever is not taken under Section I) (3)
IR 133, 134 or 135	(whichever is not taken under Section I) (3)
IR 315	The Soviet Union and the Third World (3)

Special Topics courses in other areas such as psychology or social relations with permission (3)

Field Study in the Soviet Union for academic credit under Special Topics (3)

Science, Technology and Society Program

The Science, Technology and Society (STS) Program is a broad-based effort on the part of faculty members from all colleges to foster undergraduate courses concerned with the interrelationships between scientific and technological advancement and the quality of human life.

The STS program offers a minor in Science, Technology, and Society Studies, consisting of eighteen credit hours drawn from a variety of departments. For a full description of the courses offered, see Section V.

Urban Studies

The minor program in Urban Studies is a means of gaining broad insight into the nature and potentialities of the social sciences, besides being an appropriate vocational choice for students in fields such as civil engineering, management, architecture, and social work.

Urban Studies is designed to promote basic understanding of social processes, so that students will learn to perceive in their ever-changing communities opportunities for productive enterprises of their own. For some this will mean careers in public service, but others may contribute much to the betterment of society by successful work in the private sector. The minor in Urban Studies should be of particular interest to students in the College of Engineering and Applied Science as well as the College of Business and Economics who wish to maximize the educational value of their elective courses.

The minor consists of eighteen credit hours of course work selected in consultation with the program director, based on the needs and interests of the student with due concern for the overall intellectual coherence of the program.

. Certain other courses in relevant disciplines may be included by permission of the director of urban studies, David Curtis Amidon, Jr., minor adviser, 232 Chandler-Ullmann.

required course (3 credit hours)

US 61	The Study of Urbanization (3)

elective courses (15 credit hours); from the following:

Arch 210	20th-Century Architecture (3)
Arch 213	The City (3)
Govt 77	Urban Politics (3)
Govt 328	The Politics of Urban Education Policy (3)
Govt 331	Government and Law Internship (3)
Govt 360	Public Administration (3)
Hist 333	American Urban History to 1885 (3)
Hist 334	American Urban History, 1880 to Present (3)
US 62	Contemporary Urban Issues (3)
US 125	American Ethnic Groups (3)
US 363	Philadelphia: Development of a Metropolis (3)
Eco 312	Urban Economics (3)
Eco 337	Transportation and Spatial Economics (3)
Eco 354	Public Finance: State and Local (3)
Anth 128	Urban Ethnology (3)
Anth 151	Utopias and Alternative Communities (3)

Women's Studies

The interdisciplinary Women's Studies Program, located primarily within the College of Arts and Science, seeks to broaden knowledge about issues related to sex roles and society. The program offers a minor, consisting of eighteen credit hours, that represents the major research fields of Women's Studies. This minor program is open to anyone in the three undergraduate colleges.

In every society the distinction between the sexes is a significant factor in an individual's life. Socialization according to sex affects a person's expectations about appropriate work, social relations, and political position. By focusing attention on those spheres of life in which men have played dominant roles,

traditional disciplines have tended to neglect the contribution of women to society and to underestimate the impact of gender differences upon social structure and human lives.

The women's studies minor is a supplement to any undergraduate major. It provides an integrated approach to the role of women in society from the viewpoints of a variety of academic disciplines. The program has three major goals: to promote an understanding of the traditional status and changing roles of women: to stimulate a critical examination of existing sexual roles and stereotypes and the evaluation of alternative arrangements; and to connect issues addressed in the classroom with those raised in the contexts of individual lives and society.

The minor consists of the basic course, Arts and Science 11, Sex Roles and Society, and a choice of five additional courses among those listed below. With the consent of a participating instructor, a student may substitute one Special Topics course. Students arrange their program in consultation with the director of the program, Elizabeth Fifer, department of English, Maginnes Hall.

required course (3 credit hours)

A&S 11	Sex Roles and Society: Continuity and Change (3) (team-taught by the faculty of the Women's Studies Program)

elective courses (15 credit hours)

Art 111	Women in Art (3)
Clss 152	Women in Antiquity (3)
Engl 191	Special Topics (1-3)
Engl 311	Literature of Women (3)
Govt 179	The Politics of Women (3)
Hist 325	American Social History, 1607-1877 (3)
Mgt 472	Special Topics (1-3)
Phil 221	Sex-Discrimination and the Law (3)
Psyc 131	Psychology of Women (3)
Rel 153	Sex & Gender in Religious Traditions (3)
SR 41	Human Sexuality (3)
Soc 341	Women and Health (3)
Soc 364	Lifestyle and the Family (3)

College Scholar Program

The College Scholar Program offers the qualified student a unique opportunity for maximum enhancement of critical faculties, abilities, and intellectual interests. This end is achieved through a structured program conforming to exceptional standards of breadth and rigor.

Undergraduates in the College of Arts and Science may apply for acceptance into the program at any time during the college career. An application is made to an honors committee, and acceptance is governed by the performance of the student to date and the committee's estimate of the likelihood that he or she will be able to fulfill the requirements of the program.

In order to be graduated with the designation "College Scholar," a student fulfills the requirements and achieves a cumulative average of 3.5.

Each student is required to have an individually structured program that must be approved by the director of the College Scholar Program. No course taken pass/fail may be used to satisfy the requirements. The requirements:

Area of Concentration

The major. "College Scholar" candidates may have departmental or interdepartmental majors. The academic level expected of candidates in the area of concentration can be attained by satisfactory completion of courses such as those at the 400 level, independent study, etc.

Thesis. The student takes a certain number of hours in independent study or thesis courses, culminating in a thesis or research report. This is read and rated by an ad hoc committee of three faculty members, one of whom must be from outside the department or departments in which the student is doing major work.

Comprehensive. A comprehensive examination in the area of concentration is required; it may be written, oral, or both. A committee in charge of the examination includes at least one person from a department other than that (or those) in which the student is doing major work.

Distribution Requirements

English. Engl 1 and either 2, 4, 6, 8, or 10.

Language. Proficiency in a classical or modern foreign language is needed, sufficient to complete the work of the fifth semester in any 3-3-3-3-3 sequence of credit hours; in a 4-4-3-3 sequence, completion of a fourth semester is required. There is no restriction on the language acceptable.

Mathematics. One course from among: Math 21, 31, or 41.

Natural Science. Four courses are chosen from two of the following areas: astronomy, biology, chemistry, geology, physics, and psychology. At least one of these courses shall be in chemistry or physics, and at least one of the four courses shall include the accompanying laboratory course.

Social Science. Four courses are taken from the areas of archaeology, economics, government, history, international relations, psychology, social relations, and urban studies. At least one must be in economics and one in history.

Humanities. Four courses are chosen from the areas of speech and theater, literature (English and advanced courses in classical and modern foreign languages), music, philosophy, and religion studies. At least one of these courses must be in philosophy or religion studies, one in literature, and one in the creative arts (theater, music, and art and architecture).

Note: Each of the last three requirements is stated in terms of *areas*, not *departments*, in recognition of the fact that not all humanities courses are offered in the departments whose names appear under "Humanities," not all historical courses are offered by the history department, not all philosophy courses by the philosophy department, etc.

The committee makes the decision, in consultation with the appropriate departments, under which rubric a specific course may be counted. It also is empowered to admit what substitutions it deems wise.

Pre-Law Programs

The university has a strong pre-law tradition. In keeping with the policy of the Association of American Law Schools, the university does not have a prescribed pre-law program.

Lehigh students have been successful in attaining entrance into law schools from diverse curricula within all three of the undergraduate colleges.

An active student-run Pre-Law Society brings members of the legal professional and law school personnel on campus for discussion meetings and continuously provides information about law school opportunities.

Law-related courses, some of which rely on the casebook method, are provided by both the College of Arts and Science and the College of Business and Economics. In the former, for example, there is a course in International Law. In the latter, courses in law are regularly offered by the department of law and business.

Counseling is available to prospective prelaw students on a continuous basis from freshman orientation through the law school application process in the senior year. Counselors are members of the prelaw advisory committee, composed of faculty members of both colleges. Students are urged to consult members of the committee as early as possible in their academic careers.

Details on the Law and Legal Institutions minor program are found elsewhere in this section.

Health Professions Programs

Schools of medicine, dentistry, and veterinary medicine stress the importance of a broad general education as well as prescribed studies in the sciences. As long as candidates have

the essential courses in biology, chemistry, physics, and mathematics, they may major in any of the three undergraduate colleges.

A health professions advisory committee, which includes faculty members from biology, chemistry, engineering, and physics, provides information during freshman orientation to interested students and actively works with health-professions candidates from the sophomore year forward to assist them in planning for entrance into professional schools in conjunction with their major advisers.

The university affords a special baccalaureate/doctor of medicine degree program for students interested in becoming physicians, and a doctor of dental medicine program for students interested in becoming dentists. A bachelor of arts in premedical science program is associated with the Medical College of Pennsylvania. A bachelor of arts program in predental science is available in connection with the University of Pennsylvania School of Dental Medicine. Descriptions of these accelerated courses follow.

Students interested in optometry, pharmacy, podiatry, and other allied health fields may obtain information from the health professions advisory committee in planning their courses with their academic advisers.

Accelerated M.D. Program

In cooperation with the Medical College of Pennsylvania, the university offers an accelerated six-year program that enables selected students to earn both the bachelor of arts degree in premedical science and the M.D. degree after a minimum of six years of study at the two institutions. The program was initiated in 1974, and approximately fifteen students are admitted each year.

The program includes two academic years and two summers at Lehigh, during which time ninety-five credit hours are earned toward the 121 required for the baccalaureate degree. Students entering Lehigh with sufficient advanced placement credit may minimize or eliminate the second summer session. The next four years are spent in the regular program of medical education at the medical college. After the first two years at the medical college, students will have acquired the necessary additional credit hours for the baccalaureate degree.

During the first two years at Lehigh, students are expected to make satisfactory progress in the academic areas as well as in the more subtle task of personal growth in those attributes ultimately needed as a physician. Seminars are conducted on campus by Medical College of Pennsylvania faculty members, and students are assigned to MCP faculty advisers. MCP receives student grades and monitors student progress through regular counseling sessions and feedback from Lehigh staff.

MCP has specifically avoided setting arbitrary standards for performance in order to encourage students to pursue the more difficult courses and to range into new academic and extracurricular areas appropriate to the student's academic and personal growth.

The medical college reserves the right to withdraw an offer of acceptance if academic or personal concerns cause the college to question a student's ability to function as a physician. The college also reserves the right to require that a student spend additional time at Lehigh if the medical college feels that this is necessary for the student's academic or personal maturation. Experience with the program to date indicates that such action is rarely necessary. In addition, the student may elect to take additional time at Lehigh prior to matriculation at the medical college if he or she feels that this would be beneficial. Should this occur, the student would be eligible to defer matriculation at medical school for a period of time agreed to by the student and the medical college.

Application for admission to the program is made through the Lehigh office of admission. Criteria for admission include SAT scores (minimum combined score of approximately 1300), scholastic achievement, maturity, and motivation for medicine.

Interviews are not required at Lehigh, but students are encouraged to make arrangements to come to campus to have an interview and to become better acquainted with Lehigh and the special features of the program.

Year 1: Lehigh, fall (19)	Lehigh, spring (17)
A&S1 (1)	Biol 21, 22 (4)
Chem 1, 22 (5)	Math 22 (4)
Math 21 (4)	Engl 2, 4, 6, 8, 10 (3)
Engl 1 (3)	elective (preliminary) (3)*
elective (preliminary) (3)*	elective (preliminary) (3)*
elective (preliminary) (3)*	
Summer 1: Lehigh (12)	
Chem 51, 53 (4)	
Chem 52, 54 (5)	
elective (preliminary) (3)*	
Year 2: Lehigh, fall (18)	Lehigh, spring (19)
Phys 11, 12 (5)	Phys 13, 14 (4)
Math 23 (4)	Chem 31 or 194 (3)
biology elective (3)	Biol 28 (genetics) (3)
elective (preliminary) (3)*	elective (upper)**
elective (upper) (3)**	elective (upper)**
	elective (upper)**
Summer 2: Lehigh (9)	
elective (upper)**	
elective (upper)**	
elective (upper)**	

*Preliminary distribution: two three-hour courses minimum from Area I (Humanities), Area II (Social Sciences), and Area IV (Foreign Language or Culture).
**Upperclass distribution: twenty credit-hour minimum in Areas I and II, with a minimum of two three credit-hour courses in each of the two distribution areas.

Accelerated Program in Dentistry

The university, in cooperation with the School of Dental Medicine at the University of Pennsylvania, offers an accelerated seven-year program that enables selected students to earn a combined baccalaureate and doctor of dental medicine degree after a minimum of seven years of study at the two institutions.

The program includes three academic years during which time ninety-seven credit hours are earned toward the baccalaureate degree. The next four years are spent in the regular program of dental education at the School of Dental Medicine in Philadelphia.

During the first three years at Lehigh, students are expected to make satisfactory progress in the academic areas as well as in the areas of personal growth, developing those attributes ultimately needed to become a dentist. Students must maintain a minimum 3.0 grade-point average throughout their three years at Lehigh.

The dental school reserves the right to withdraw an acceptance if academic or personal concerns cause the college to question a student's ability to function as a dentist. The dental school also reserves the right to require that students spend additional time at Lehigh if the school feels that this is necessary to insure the student's academic or personal maturation.

Application to the program occurs when a student applies to Lehigh University. The dental school takes action on the applicant and interviews candidates from mid-February to mid-March of an academic year. Final decisions are forwarded to Lehigh University about March 20. The applicant is notified of joint acceptance by Lehigh University. Admission is based on SAT scores (a minimum combined score of 1200), scholastic achievement, maturity, and motivation for dental school.

Year 1, fall (14)	spring (16)
A&S 1 (1)	Biol 21, 22 (4)
Chem 21, 22 (5)	Math 44 (3)
Math 41 (3)	Engl 2 (3)
Engl 1 (3)	elective* (3)
elective* (3)	elective*(3)
Year 2, fall (15)	spring (17)
Chem 51 (3)	Chem 52, 55 (5)
Biol 28 (3)	Biol 235 (3)
elective* (3)	Math 42 (3)
elective* (3)	elective** (3)
elective* (3)	elective** (3)

Year 3, fall (17)	spring (16)
Phys 11, 12 (5)	Phys 13, 14 (4)
Biol*** (3)	Biol*** (3)
elective** (3)	Chem 31 (3)
elective** (3)	elective** (3)
elective** (3)	elective** (3)

*Preliminary distribution: two three-hour courses minimum from Area I (Humanities), Area II (Social Sciences), and Area IV (foreign Language or Culture).
**Upperclass distribution: twenty hours in Area I and Area II with a minimum of two three credit-hour courses in each of the two areas.
***Approved program courses with consent of adviser.

College of Business and Economics

Richard W. Barsness, *dean*;
Joseph P. Klein, *assistant dean*

The College of Business and Economics offers the bachelor of science degree in business and economics, which couples a liberal educational background with an understanding of the complexities and processes of management. It can serve as the basis for a career in business or for professional studies in fields such as law, business, or related fields. Qualified students can opt to continue their studies for a fifth year and earn a master of business administration degree.

The undergraduate business program, undergraduate accounting program, and MBA programs are accredited by the American Assembly of Collegiate Schools of Business (AACSB), of which the College of Business and Economics is a member. The college offers a program of undergraduate study designed to provide an understanding of the complexities of the managerial process in society, both within and outside the business firm.

Many of the most difficult societal problems today involve decision-making, conflict resolution, and the efficient and effective management of human and physical resources. Studies of business and economics provide fundamental bases for understanding and approaching solutions to aspects of these problems, particularly as they present themselves to business leaders and administrators in other fields.

Thus the college's undergraduate business program stresses analytical and communication skills for the development and articulation of problem-solving techniques. Educational breadth equivalent to many liberal arts programs is accompanied by depth of study of business processes such as accounting information systems, financial flows and markets, management processes, and the impact of economic variables and forces upon business and social issues.

Major Subjects

Five major programs are offered, each leading to the bachelor of science degree. The programs include:
accounting
economics
finance
management
marketing

Breadth of Study

In essence, the undergraduate education deemed most suitable for young men and women who will be the business leaders of tomorrow is formulated as analytically rigorous but with broad educational foundations combined with in-depth understanding of business processes in the economy in which we live.

This education in fundamentals, principles, and problem-solving techniques provides graduates with various options. Some of the students choosing this curriculum have already settled upon business careers. Others will use it as a base for further professional studies in law, graduate business schools, or specialized graduate training in economics, operations research, or other related fields. Still others go into administrative careers in government or nonprofit institutions such as hospitals and universities. Others apply their talents to professional accounting, financial investment, or management consulting careers. Others teach economics or administrative science.

Undergraduate education must first provide the solid base of analytical skills and acquaintance with a segment of significant and relevant phenomena of our society. Equipped then with learning skills and intellectual facility in problem solving, the student's ultimate career must be of his or her own making.

Business today cannot be approached with narrow or superficial vocational training. Its problems are strongly conditioned by the state of the economy and even by social issues confronting modern business executives. Thus a strong basis in the social sciences is essential to understanding the nature of business organizations. The student must also be familiar with physical sciences and technology. Finally, mathematics and computer systems are essential elements of modern decision-making processes. An introduction to all of these is provided in the undergraduate program in business and economics.

There are six departments through which much of the student's work is carried out: accounting, economics, finance, law and business, and management and marketing.

Variety of Options

The student of today must be provided with options. Initiative and motivation would be stultified in a straightjacketed curriculum. To avoid such rigidity, the necessary exposures to science, language, and other arts are accomplished by optional requirements, within each of which the student has wide choice. Thus the basic curriculum rationale is similar to a distribution requirement in liberal arts to guarantee breadth of undergraduate educational experience. Additionally, however, approximately twenty credit hours required for graduation are completely open for selection on a free-elective basis.

The degree of bachelor of science in business and economics may also lead to achievement of the master of business administration degree in the college or at another institution for qualified students.

In addition to the master of business administration, the college also offers the following post-baccalaureate degrees: the doctor of philosophy, the master of arts, the master of science, and the master of science in management science. These are described in Section IV.

Goals of the College

The objectives of the College of Business and Economics are to provide an understanding (at the undergraduate level) and managerial and/or research-teaching expertise (at graduate levels) of the nature of business enterprise decision-making and resource management in the economy. Undergraduate objectives may be summarized as follows:

- Through a common body of knowledge, to stimulate interest in and acquaint a student with basic business and economic systems of resource allocation, financial management, management of human and physical resources, information systems, financial and managerial accounting, pricing and distribution;
- To provide breadth of appreciation of the scientific, technological, social and human features of the world in which business is carried on;
- To provide tools which permit rigorous analysis of business problems and to foster a capacity for continuing professional development;
- To engage in depth in advanced courses with upperclass students, both as a prelude to professional careers or to graduate education;
- Through a major, to provide each student with an in-depth learning experience in at least one area of business or the economy in which business operates, such as accounting,

finance, economics, economic statistics, foreign careers, management or marketing;
• To increase written and oral communication skills.

Centers and Institutes

The college also oversees research and scholarship in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Center for Advanced Technology for Large Structural Systems, Center for Economic Education, Center for Innovation Management Studies, Center for Social Research, Fairchild-Martindale Center for the Study of Private Enterprise, Institute for the Study of Commodities, Rauch Center for Executive Development, Technology Studies Resource Center.

The college is also associated with the International Business Institute in the Center for International Studies.

Bachelor of Science in Business

To obtain the bachelor of science degree in business and economics, 123 credit hours are required.

Beginning with the class of 1991 (entering freshmen of 1987), a "writing skills" requirement will be a part of the college curriculum requirements for all students in the College of Business and Economics.

College Core Requirements (58 credits)

English and mathematics (12 credits)

Engl 1	Composition and Literature (3)
Engl 2, 4, 6, 8 or 10	Composition and Literature: Fiction, Drama, Poetry (3)
Math 41	BMSS Calculus I (3)
Math 44	BMSS Calculus II (3)

Note: BMSS stands for biological, management and social science.

Business and economics core (46 credits)

Eco 1	Economics (4)
Mgt 1	Introduction to Business Computing (3)
Eco 145	Statistical Methods (3)
Eco 229	Money and Banking (3)
Eco 105	Intermediate Microeconomic Analysis (3)
Eco 119	Intermediate Macroeconomic Analysis (3)
Acct 51	Introduction to Financial Accounting (3)
Acct 52	Introduction to Managerial Accounting (3)
Acct 111	Management Information Systems in Business (3)
Law 201	Legal Environment of Business (3)
Mkt 211	Contemporary Marketing (3)
Fin 225	Business Finance (3)
Mgt 269	Management of Operations in Organizations (3)
Mgt 270	Organization Theory and Behavior (3)
Mgt 301 or Mgt 306	Business Management Policies (3) or Entrepreneurship and Business Policy (3)

Major Program (15 credits)

Before the end of the first semester of the junior year, students select a major or field of concentration. A major program consists of sequential or related courses in accordance with one of the designated major programs, as detailed in Section V. Five majors are offered: accounting, economics, finance, management, and marketing.

Optional Courses (30 credits)

The student elects three credit hours of courses from each of the following four groups:

1. Offerings in English, speech, journalism, theater, or modern foreign languages.
2. Offerings in the government, history, international relations, psychology, and social relations departments (including urban studies).
3. Offerings in the art and architecture, classics, mathematics, music, religion studies, and philosophy departments.
4. Offerings in the biology, chemistry, geological sciences, and physics departments.

The remaining eighteen credit hours are taken in any one or more of the departments listed in the four groups above or any one or more departments in the College of Arts and Science, as follows: biology, classics, English, art and architecture, geological sciences, government, history, international relations, mathematics, modern foreign languages and literature, music, philosophy, psychology, religion studies, and social relations. One-hour courses are not accepted for the optional courses but may be counted toward electives.

Electives (20 credits)

Normally, any courses for credit in the university for which a student has the prerequisites may be used as electives.

Advanced military science and aerospace studies courses may be counted as electives up to six credits, but freshman- and sophomore-level courses in military science and aerospace studies do not carry credit against the 120 credit hours required for graduation.

Planning Courses of Study

In addition to freshman English and mathematics requirements, each freshman enrolled in the College of Business and Economics registers for Eco 1 and/or Mgt 1.

For the fourth and possibly fifth courses, the freshman student takes courses toward the optional requirement each semester of the freshman year. The normal program for freshmen is fifteen credit hours each semester.

Acctg 51 is taken in the first semester of the sophomore year. Other business and economics core requirements should be selected with some sampling of introductory courses that may help the student choose the major in the junior year.

The pass-fail option is available for students in the college for elective credits. Courses with passing letter grades must be submitted to meet the core, major program, and optional requirements. Courses taken on a pass-fail basis are classified as elective courses. Students desiring to obtain Lehigh credit for courses taken at other institutions must obtain a petition form from the registrar's office and obtain the approval of appropriate Lehigh academic departments *in advance*. The senior-year work must be taken at Lehigh.

Course Sequence

Freshman Year

first semester		*second semester*	
Engl 1	3 credit hours	Engl 2, 4, 6, 8, 10	3 credit hours
Math 41	3	Math 44	3
Eco 1	4	Mgt 1	3
electives	6	electives	6
	16 credit hours		15 credit hours

Note: The college assigns students to take Eco 1 in either the fall or spring semester. A similar assignment is made for Mgt 1. The student registers for six credit hours of electives in both semesters to round out the normal course load.

Sophomore Year

first semester		*second semester*	
Acctg 51	3 credit hours	Acctg 52	3 credit hours
Eco 145	3	Acctg 111	3
Eco 105	3	Eco 119	3
electives	6	electives	6
	15 credit hours		15 credit hours

Note: Many sophomore courses can be taken in either semester.

College of Education

The university's College of Education offers opportunities for advanced study in the field of education. For information, see Graduate Study in Education, Section IV, or College of Education, Section V.

College of Engineering and Applied Science

Donald M. Bolle, *dean;* Curtis W. Clump and Alan W. Pense, *associate deans*

The College of Engineering and Applied Science offers the bachelor of science degree in thirteen programs, combining a strong background in sciences and mathematics with General Studies requirements in humanities and social sciences. Students in college programs learn principles they can apply in future professional work; those who plan on further academic experience can design a curriculum centering on interests they will pursue in graduate school.

In the past engineering education was identified in terms of the needs of industry. Present-day engineering programs continue to provide and emphasize such preparation. However, the flexibility inherent in the curricula enables students to design personalized programs leading directly into other professional colleges or professions such as medicine, law, government, management, or architecture.

The college encourages such mobility. Experience shows that the background provided through the college programs, including "the engineering approach" to identification, articulation and resolution of problems, finds increasingly wider applicability in those areas of activity that call for a combination of practical and conceptual intelligence.

The college recognizes that the four-year programs are not intended to train specialists in a given area but rather to educate students in terms of principles they will apply to problems they encounter in their future professional work.

The applied curricula of the college stress fundamentals while providing opportunities for electives in each of the substantive fields within the sciences. Senior-year programs in the sciences can be planned to facilitate transition to either graduate school or industrial laboratories.

Major Subjects

The College of Engineering and Applied Science includes six departments and offers undergraduate and graduate degree programs at the bachelor, master, and doctor of philosophy levels.

The undergraduate degree programs or curricula leading to the bachelor of science degree are:

chemical engineering*
chemistry or biochemistry
civil engineering*
computer science
computer engineering
electrical engineering*
fundamental sciences
industrial engineering*
mechanical engineering* and mechanics*
materials science and engineering*
physics

*Accredited by the Accreditation Board for Engineering and Technology. Programs in chemistry and physics have been approved by the program review committee in these disciplines.

Information about each of these programs may be found under alphabetical listings in Section V.

Each of the curricula includes course requirements in the physical sciences, mathematics, engineering sciences, and the advanced engineering or science course work essential for the particular degree. In addition, each curriculum has General Studies requirements in the humanities and social sciences.

Undergraduates with interests in such topical areas as environmental control, biotechnology, or aerospace can pursue their interests through electives provided in each of the curricula. Effective preparation for graduate study in such specialties consists of basic programs in engineering and science, along with electives especially chosen for the field of interest. Such electives are chosen from among all the offerings of the university and usually taken during the senior year.

Note: On July 1, 1987, the departments of chemistry and physics will move from the engineering college to the College of Arts and Science, where they will join the other science departments. Because the change is primarily related to the university's organization, students enrolled in chemistry and physics programs will not be significantly affected in their course work.

Recommended Freshman Year In Engineering and Applied Science

The following is the recommended outline of work for the freshman year, satisfying the requirements for all students in the college. For schedules of the work required in the following three years, refer to Section V.

Freshman year, first semester (15-16 credits)

Engl 1	Composition and Literature (3)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5) **or**
Phys 11, 12	Introductory Physics I and Laboratory (5)
Math 21	Analytic Geometry and Calculus I (4)
Engr 1	Engineering Computations (3) **or**
General Studies, elective (3 or 4)	Humanities, or Social Science (GS) elective (3-4)

Freshman year, second semester (15-16 credits)

Engl 2	Composition and Literature: Fiction, Drama, Poetry (3) *
Phys 11, 12	Introductory Physics I and Laboratory (5) **or**
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Math 22	Analytic Geometry and Calculus II (4)
Engr 1	Engineering Computations (3) **or**
General Studies, elective (3 or 4)	Humanities, or Social Science (GS) elective (3-4)

*Engl 4, 6, 8, or 10 may replace Engl 2.

Personal Electives

The college, through its advisers, is prepared to help students to use the six credit hours of "free electives" that, along with other electives in the curriculum, may be used to develop a program of personal interest. Free electives may be satisfied by taking regular course offerings or six credit hours from Mus 21-78, or six credit hours from Jour 1-8, or six credit hours of advanced ROTC courses.

Students who do a co-op assignment or have significant involvement in noncredit major extracurricular activities may have up to six credit hours of free electives waived upon petition to the department chairperson. These petitions must be completed and approved *prior* to the final semester before graduation.

Qualified juniors in the college planning to continue their formal education in graduate school are urged to take advantage of the flexibility in their programs and design their senior-year "free elective" opportunities in a manner that provides an effective foundation for a graduate program. Students who plan their programs in this manner can, upon recommendation of the department and with the approval of

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General Studies Program: Humanities for Engineers

The General Studies (GS) program involves a minimum of twenty-five credit hours normally spread over four years. It is designed to enable students to range widely or to delve deeply into the humanities or the social sciences with the purpose of exploring the value systems, assumptions, and methodologies contained in these areas.

Since all students in the college are expected to complete specified sequences of courses in the physical sciences, and other electives are available for related courses in natural sciences, the General Studies program is restricted to the humanities and social sciences.

In addition, students pursuing a bachelor of science degree program in the college can, if they so choose, organize their General Studies program to achieve a minor in any one of the established areas in the humanities or social sciences. This requires:

1. Identifying the area of interest, i.e., sociology, philosophy, art and architecture, literature, etc., and obtaining the approval of the director of the General Studies program. A conference with the director is the first step toward this goal.
2. Formulating a course program in the area of concentration jointly with a member of the faculty representing the area of concentration. The names of faculty representatives are given to students by the director of General Studies.

In general, the minor is earned upon successful completion of a program of not less than fifteen credit hours in the area of concentration. In each and every case the faculty adviser in the area of concentration or the director of General Studies must recommend the student's work for such recognition. It is desirable that students planning to earn a minor in General Studies initiate action soon after their freshman year but not later than the beginning of the fifth semester.

The General Studies sequence of the college starts in the freshman year with six hours of English composition and literature, and a three-credit-hour social science or humanities elective. In the sophomore year, four credit hours of economics are required. By the end of the senior year, a minimum of twelve additional credit hours (four courses) is completed to satisfy the requirement of a total of twenty-five credit hours in General Studies.

Courses qualifying for credit in General Studies are as follows:

Required Courses (10 credit hours)
Engl 1 or 11, and one course from among Engl 2, 4, 6, 8, 10 or 12; Eco 1

Electives in humanities and social science (15 credits)
Art and architecture, any except Arch 145

Classics, any course

Computer Science

CSc 252	Computers and Society (3)
CSc 301	Descriptive Linguistics (3)

Economics

Eco 105	Intermediate Microeconomic Analysis (3)
Eco 119	Intermediate Macroeconomic Analysis (3)
Eco 229	Money and Banking (3)
Eco 303	Economic Development (3)
Eco 305	The Economic Development of Latin America (3)
Eco 309	Comparative Economic Systems (3)
Eco 310	Economic Evolution (3)
Eco 311	Environmental Economics (3)
Eco 312	Urban Economics (3)
Eco 313	History of Economic Thought (3)
Eco 314	Energy Economics (3)
Eco 334	Labor-Management Relations (3)
Eco 335	Labor Economics (3)
Eco 336	Business and Government (3)
Eco 337	Transportation and Spatial Economics (3)
Eco 340	International Finance (3)
Eco 343	European Economic Integration (3)

English, any course

Foreign language, any advanced course. If elementary modern language study is elected, a minimum of one year must be in one language in order to receive General Studies credit.

A student may not elect an elementary course in any language studied in high school without approval of the department of modern foreign languages.

Freshman Seminar

Government and Urban Studies, any course

History, any course

International Relations, any course

Journalism

Jour 114	Reporting of Public Affairs (4)
Jour 118	History of American Journalism (3)
Jour 121	Law of the Press (3)
Jour 122	Law of the Press II (3)
Jour 123	Basic Science and Technical Writing (3)
Jour 124	Politics of Science (3)
Jour 125	Environment, the Public and the Mass Media (3)
Jour 131	Science Writing Practicum (1-3)
Jour 141	Photojournalism (3)
Jour 211	Problems in Advanced Reporting (3)
Jour 311	Science and Technical Writing (3)
Jour 312	Advanced Science Writing (3)
Jour 313	Special Topics in Science Writing (3)
Jour 315	Interpretive Writing (3)

Law 11 Introduction to Law (3)

Music, any course other than Mus 21 through 78

Philosophy, any course except Phil 14

Psychology

Psyc 1	Introduction to Psychology (3)
Psyc 11	Introduction to Psychology: Discussion Format (3)
Psyc 65	Perception and the Visual Arts (3)
Psyc 77	Drugs and Behavior (3)
Psyc 81	Psychology and Law (3)
Psyc 107	Child Development (3)
Psyc 108	Adolescent Development (3)
Psyc 115	History of Modern Psychology (3)
Psyc 117	Cognitive Psychology (3)
Psyc 131	Psychology of Women (3)
Psyc 154	Introduction to Clinical Psychology (3)
Psyc 201	Industrial Psychology (3)
Psyc 305	Abnormal Psychology (3)
Psyc 331	Humanistic Psychology (3)
Psyc 351	Cognitive Development in Childhood (3)
Psyc 353	Personality Theory (3)
Psyc 354	Personality Assessment (3)

Science, Technology and Society, any course

Religion Studies, any course

Social Relations, any course except SR 111, 112, 343, 377, Soc Psych 391, 392

Speech and Theater

Thtr 1	Introduction to Theater (3)
Thtr 15	Introduction to Technical Theater (3)
Thtr 113	Stage Lighting (3)
Thtr 115	Scene Design (3)
Thtr 117	Theater History (3)
Thtr 118	Introduction to Theater History II (3)
Thtr 121	Acting II (3)
Thtr 141	Acting III (3)
Thtr 144	Basic Directing (3)
Thtr 151	Costume Design (3)
Thtr 245	Advanced Directing (3)
Thtr 271	Playwriting (3)

the dean of the Graduate School, receive credit towards their degree for up to six hours of graduate-level courses.

Technical Minors

In addition to the General Studies minor, other minors are offered in technical or scientific specialties that are not normally included within the normal curricula. Each program contains at least fifteen credit hours of technical and/or scientific courses. Often some of these courses can be chosen as approved electives in the student's major curriculum; others are chosen as free electives.

Technical and scientific minors are available in chemical processing (not open to chemical engineers), molecular biophysics (not open to engineering physicists or fundamental sciences majors concentrating in this area), production management (not open to industrial engineers), fluid mechanics, and solid mechanics.

In some special cases a student in the college, able to incorporate electives within the curriculum that happen to satisfy the requirements of a minor offered in the College of Arts and Science, can, with the permission of the adviser in that college, earn the minor.

Change of Curriculum

The early indication of curriculum choice by students in their application to the university is not a commitment on their part. In the second semester of the freshman year, at preregistration for the sophomore year, students usually indicate their choice of curriculum.

However, since the sophomore-year programs for several curricula are very much alike, it is possible to transfer from one curriculum to another as late as the end of the sophomore year. This is done by means of a petition following consultation with curriculum advisers. There are instances where such a transfer may require one or two courses to be taken during a summer session at Lehigh or elsewhere.

Five-year programs combining the liberal arts and engineering or electrical engineering and physics are also available. In each of these combined curricula, one bachelor degree is awarded upon the successful completion of four years of study, and a second bachelor degree is awarded at the end of the fifth year.

The college curricula are designed to provide students with as much latitude as can be made available without compromising the balance and integrity expected of them by accrediting agencies.

Centers and Institutes

The college also oversees research and scholarship in a number of centers and institutes, where graduate and undergraduate students work closely with faculty members. These include: Center for Advanced Technology for Large Structural Systems, Biotechnology Research Center, Center for the Application of Mathematics, Center for Design and Manufacturing Innovation, Center for Environmental Studies, Center for Health Sciences, Center for Innovation Management Studies, Center for Surface and Coatings Research, Chemical Process Modeling and Control Center, Emulsion Polymers Institute, Energy Research Center, Fritz Laboratory, Institute for Robotics, Institute for the Study of the High-Rise Habitat, Institute of Fracture and Solid Mechanics, Institute of Metal Forming, Institute of Thermo-Fluid Engineering and Science, Materials Research Center, Sherman Fairchild Center for Solid-State Studies, The Stone Harbor Marine Laboratory.

The General College Division

The General College Division supplements the mission of the established undergraduate curricula by providing: an opportunity for persons not planning to qualify for a degree to pursue work, either of a general or specialized nature, which their preparation and interests make desirable; a trial period for those who wish to become candidates for baccalaureate or graduate degrees, but whose preparation does not satisfy the entrance requirements for the established curricula; and an opportunity for qualified students to continue their education without being committed to a restricted or specialized program of studies. Courses taken in the General College Division may not be submitted to meet the requirements for a graduate degree.

For admission to the General College Division, the applicant must show maturity, seriousness of purpose, and evidence of ability to pursue with profit the program of studies he or she desires. The student must have the established prerequisites for courses in which he or she wishes to enroll, and may register for courses up to and including the 300-level.

There is no established curriculum for the General College Division. Each student works on a program outlined to meet his or her special needs. Each program must be approved by the director of the division.

Students in the division are not candidates for degrees. A student may transfer to regular matriculated undergraduate status in any of the colleges only upon petition to, and with the approval of, the committee on standing of students. Transfer to the graduate school is possible only through the normal graduate admission process.

Transfers from regularly matriculated status in any of the colleges to the General College Division may be made only with the approval of the committee on standing of students. Transfers from the Graduate School require the approval of the graduate committee.

With the exception above, students in the General College Division are subject to the same rules and regulations as students of the university. They pay the tuition and fees established for regularly matriculated students.

Continuing Education and Summer Sessions

Lehigh University departments, research centers, and administrative agencies offer a varied selection of continuing education programs for adults. Reflecting Lehigh's educational strengths, these offerings include career enrichment, professional development, and sophisticated technical training programs. They often provide tools and techniques applicable to specific problems of corporations and other organizations. These programs carry no regular academic credit, but participants can earn Continuing Education Units (CEUs). In awarding CEUs, Lehigh follows the guidelines developed by the National Council on the Continuing Education Unit.

Lehigh continuing education programs are self-contained educational packages designed to meet specific needs. Their content, schedules, and timing are adapted to best serve the audiences for which they have been developed. Continuing education instructors are generally drawn from the Lehigh faculty, but distinguished men and women from industry and other educational institutions are often involved as well. A number of programs are available for "in-house" presentation to organizations on a contract basis.

Summer sessions have been conducted at Lehigh University for nearly a century. Presently featuring more than 200 credit courses, this program serves Lehigh's regular graduate and undergraduate population, area teachers and other professionals, and students from other institutions of higher learning who return to their homes in the Lehigh Valley during the summer. At Lehigh, the summer is a time in which experimentation is encouraged. The result is often innovative courses that are unavailable at other times of the year.

For more information about continuing education or summer sessions at Lehigh, contact the Office of Continuing Education and Summer Sessions, 219 Warren Square, Lehigh University, Bethlehem, Pa. 18015, (215) 758-3935 or (215) 758-3966.

"Reading loco. that pulled us to Phila. 1905." Students in that era frequently used rail transportation.

IV.

Advanced Study and Research

The Graduate School

Jerry P. King, dean

Lehigh in 1982 marked the hundredth anniversary of the granting of graduate degrees. Although the intention of granting advanced degrees was announced at the founding of the university in 1865, the first graduate degree, a master of arts, was awarded in 1882 to T.H. Hardcastle, Class of 1880, who wrote his thesis on Alexander Pope and delivered his master's oration, "The Rights of Man," at commencement in June, 1882.

The first Ph.D. was granted in 1895 to Joseph W. Richards, Class of 1886. Richards, who had a background in metallurgy and electrochemistry, taught at Lehigh until his death in 1921.

Women were admitted to the graduate program in 1918 when the faculty and the board of trustees agreed to grant the degrees of M.A. and M.S. to women, provided they attended classes in the late afternoon and on Saturdays "so that the general character of campus life shall not be affected." Three women received graduate degrees in 1921, the first women to complete graduate work at Lehigh. In 1929, the rule was changed, and women were admitted on much the same basis as men.

In 1936, the Graduate School was established to administer the graduate program. The Ph.D., which was temporarily discontinued in 1894, was reinstated in nine departments: chemistry, chemical engineering, geology, history, mathematics, mechanical engineering, metallurgical engineering, and physics. Tomlinson Fort, professor of mathematics, was selected in 1938 as the first dean of the Graduate School.

Despite this demonstrated interest in graduate education, it was not until 1961 that the university officially resolved to strengthen and expand graduate programs university-wide. Since then, graduate work has assumed increased importance and prominence, and facilities and funding have increased tremendously. The present dean of the Graduate School, Jerry P. King, was appointed in January 1981, to succeed Robert D. Stout, who was dean from 1960 until his retirement in 1980.

College of Arts and Science

John W. Hunt, dean

Within the College of Arts and Science, professionally oriented students may pursue advanced degrees in biology (M.S., Ph.D.), English (M.A., Ph.D.), geology (M.S., Ph.D.), government (M.A., M.P.A.), history (M.A., Ph.D.), mathematics (M.S., Ph.D.), psychology (M.S., Ph.D.), social relations (M.A.)., and applied social research (Ph.D.). Although degree requirements vary from department to department, most departments require a combination of formal coursework and independent research. Students work closely with a faculty adviser both in formulating and carrying out their research programs. Given the nature of the liberal arts, these programs commonly involve faculty and/or coursework from more than one department or a department and research center/institute. Students interested in such an interdisciplinary approach are admitted to a single department but formulate a program of study and research that draws on faculty and and facilities in other areas of the university. Superior candidates may qualify for financial support in the form of teaching assistantships, graduate assistantships, research assistantships, scholarships, or university fellowships.

College of Business and Economics

Richard W. Barsness, dean

The Graduate School, in conjunction with Lehigh's College of Business and Economics, offers the master of arts and master of science degrees in business and economics, master of business administration, master of management science, and the doctor of philosophy degree in business and economics.

Graduate education in the College of Business and Economics distinguishes by emphasis between professional management training through the M.B.A., which generally, though not always, concludes at the master's level, and graduate pursuit of business and economics subjects in depth for research and/or teaching expertise through the doctoral and related M.A. or M.S. programs.

There are five departments in the college: accounting; economics; finance; law and business; and management and marketing. Course descriptions can be found listed under these departments in Section V; more information about the various degree programs appears below. The college publishes a brochure describing its graduate programs, which may be obtained by writing to the Graduate School, Whitaker Laboratory 5, Bethlehem, Pa. 18015.

College of Education

Paul VanR. Miller, dean

The College of Education operates in conjunction with the Graduate School with regard to admission, registration, tuition, fees, transcripts, and other related matters. Degree requirements are also consistent with those established by the Graduate School.

The College of Education offers the master of arts in education, the master of education, the master of science in education, the educational specialist, the doctor of education, and the doctor of philosophy. More information about these degrees appears below.

The College was established as the School of Education in 1966, elevating it from its former departmental status under the College of Arts and Science. In 1985 the school was given its present status as a college, headed by a dean. The College is engaged in the preparation of elementary and secondary teachers in both school and nonschool settings, school and community counselors, counseling psychologists, school psychologists, school and college administrators, reading specialists and supervisors, curriculum specialists and supervisors, specialists in the foundations of education, specialists and supervisors in the education of mentally and emotionally disturbed children, teachers of preschool children (especially children with handicaps), teachers for the social restoration of potential delinquents, and specialists in educational technology.

The College of Education is interested in potential and established leaders in all aspects of educational endeavor. More than 500 students were involved in advanced study at the master's and doctoral levels during the 1985-86 academic year.

Through its working relationship with other colleges and universities in eastern Pennsylvania, Lehigh has undertaken to complement existing undergraduate preparation programs by emphasizing study at the graduate level. Off-campus course work and in-service projects are integral parts of many programs.

An intern teaching program is specifically designed for qualified persons who hold bachelor of arts degrees and who desire to enter the field of teaching. Those admitted to this program have the opportunity to accomplish their professional training and serve as interns in the public schools. After two semesters of directed full-time study, students may begin the teaching internship. Upon completion of the fifth-year program and the required semesters of intern teaching, these students ordinarily will have completed requirements for the M.A. (secondary teachers) or the M.Ed. (elementary teachers), as well as state certification.

Organization. The College of Education is organized into two departments and eight program areas. The departments are the Department of Counseling Psychology, School Psychology, and Special Education, and the Department of Leadership, Instruction, and Technology. The eight program areas, each having its own coordinator, are administration and supervision, counseling, educational technology, reading, school psychology, social restoration, special education, and teacher education.

Centennial School. The College of Education operates the Centennial School—a laboratory facility for exceptional children that has both an elementary and a secondary component. Centennial School provides research opportunities as well as practical experience for advanced students in counseling, school psychology, special education, and reading. The laboratory facility is housed in a former elementary school in the Bethlehem community.

Undergraduate minor in education. Upper-level undergraduates are given an opportunity to take a minor in education that combines practicum activities with theoretical work and is designed to provide a foundation for further educational studies at the graduate level.

College of Engineering and Applied Science

Donald M. Bolle, dean

The College of Engineering and Applied Science offers the master of science, master of engineering, doctor of philosophy and doctor of arts degrees in each of its eight academic departments and in interdisciplinary programs. Each department creates its own course, examination, and thesis or dissertation requirements within the framework of those established by the Graduate School. The departments in the college offering graduate degrees are chemical engineering, chemistry, civil engineering, computer science and electrical engineering, industrial engineering, mechanical engineering and mechanics, materials science and engineering, and physics. The college's interdisciplinary programs include applied mathematics, manufacturing systems engineering, and polymer science and engineering.

Graduate study in the College of Engineering and Applied Science is closely related to the college's extensive scholarly and research activity, and all graduate students are expected to engage in anaytical or experimental research as part of their programs of study. This activity involves students in the process of creation of new knowledge under the direction of the college's distinguished faculty and brings them into contact with some of the most modern and advanced experimental techniques. Many college research programs are supported by

contracts, fellowships, and grants from industry and from federal, state, and local governments. This funding not only provides financial support for outstanding students but also allows them to deal with some of the more complex and pressing problems facing our society now and in the 21st century.

Many faculty members and graduate students in the College of Engineering and Applied Science are associated with interdisciplinary research centers and institutes as well as with their own departments. This opportunity for interdisciplinary study allows them to cross departmental lines in specific technological areas and to work with faculty and graduate students from other departments. Centers and institutes currently carry on research in the areas of biotechnology, applied mathematics, health sciences, thermofluids, materials, energy, marine and environmental sciences, surfaces and coatings, solid-state studies, structural and geotechnical studies, high-rise habitats, emulsion polymers, fracture and solid mechanics, metal forming, robotics, computer integrated manufacturing, and design and management innovation. Extensive research in many of these areas is also conducted with academic departments. All students in interdisciplinary degree programs are associated with specific academic departments.

Admission to the graduate program

A graduate of an accredited college or university may be considered for admission to the Graduate School. The decision to admit a student ordinarily rests with the applicant's major department and stands for one year following the first semester for which admission was offered. If more than one year elapses, the prospective student's department reserves the right to reconsider the original offer.

Applications for admission may be obtained by writing to the Office of the Graduate School, Whitaker Laboratory 5, Lehigh University, Bethlehem, Pa. 18015.

An applicant may enter the graduate program as a student in one of two categories: regular or associate. Except for qualified Lehigh undergraduates, only those who have been admitted officially by the graduate admission office either as regular or associate graduate students may register for graduate courses or take them for credit. (A graduate course is one at the 400 level or higher.)

Regular graduate students. Only regular graduate students are candidates for graduate degrees. Application for admission as a regular graduate student must be filed at least thirty days prior to the start of graduate registration. In order to be considered for admission as a regular graduate student, the applicant must satisfy at least one of the following conditions: have an undergraduate G.P.A. of at least 2.75 out of 4.00; have an average of at least 3.00 for the last two semesters of undergraduate study; have scores at or above the 75th percentile on the Graduate Record Examination or other recognized test (all foreign graduate students are required to take the test of English as a foreign language and achieve a minimum score of 500); have a graduate grade-point average of at least 3.00 for a minimum of twelve credit hours of graduate work completed at other institutions; or have successfully satisfied the probationary conditions as an associate graduate student discussed below. Satisfying one of these conditions is a necessary but not sufficient condition for admission as a regular graduate student.

Individual departments may evaluate their candidates for admission according to higher standards and additional criteria. Departments should be consulted for information regarding required examinations for admission. For example, candidates for the M.B.A. program are required to take the Graduate Management Admission Test (GMAT).

Associate graduate students. Applicants for admission to associate graduate student standing will be reviewed while regular graduate student applications are being evaluated. Associate graduate status may be offered to applicants who apply but fail to qualify for regular graduate status. Only associate graduate student applications will be considered during the late admission period between the end of the regular admission period and the first day of classes. Associate graduate students who are admitted at this time and who clearly qualify for admission as regular graduate students may petition for regular status after classes begin if all credentials are in order. There is no late application fee.

Applicants for associate status complete a simplified application form which requires an unofficial rather than official transcript; letters of recommendation are not required. The registrar will require an official final transcript, however, before grades are released.

Enrolled associate graduate students may apply for regular graduate student status when the following condition is met: completion of the first nine credit hours of courses numbered 300 or higher with at most one grade of C, C+, or B−. All other grades must be B or higher. A student receiving a grade of C− or lower will be dropped from the program. Individual departments may impose more rigorous probationary standards.

When the probationary period of nine credit hours is completed successfully, an associate student must petition for regular student status in order to continue. This will require the submission of regular admission documents not already on file. Courses completed during a successful probationary period may count toward a graduate degree if they are part of an approved program.

Lehigh University undergraduates. A Lehigh undergraduate may take any 400-level course for which he or she is qualified. The qualifications are defined by the department, and are certified by the course instructor and department chairperson through petition to the graduate committee.

Undergraduates at Lehigh who are within a few hours of meeting the requirements for a baccalaureate degree may, with the special approval of the graduate committee, enroll for a limited amount of study for graduate credit. Lehigh undergraduates may apply course credits taken in the undergraduate program toward a graduate degree under the following conditions: (a) the course credits are not submitted as part of the requirement for an undergraduate degree; and (b) courses for possible graduate credit are approved in advance by the course instructor, department chairperson, and dean of the Graduate School. The student must receive a grade of B− or better.

Readmission. A student who has not been registered in a Lehigh graduate program for five years must petition for re-entry. Petitions approved by the student's major department must be forwarded to the dean of the Graduate School.

Registration

Requirements. All graduate students using Lehigh University resources must be registered. In order to maintain full-time enrollment status, a graduate student must ordinarily register for a minimum of nine credits each semester. No graduate student may register for more than fifteen credits per semester. The maximum registration in a summer session is six credits. (An audit is worth 0 credits.)

Registration procedure. Graduate registration is held during the week preceding the start of classes. Students should contact their departments for a schedule of days advisers will be available to register students. Education students should check with their departments for registration and semester class schedules.

To register, graduate students should complete registration forms and personal data sheets available in their departments. A course adviser will discuss course selections with students and sign registration forms upon approval. When registration forms have been signed, fellowship and scholarship holders go to the Graduate School office, in Whitaker Laboratory, for the dean's signed approval of their tuition awards. Teaching assistants and graduate assistants must receive the signed approval of the dean of their college or the appropriate vice president. Students whose tuition is some form of employee benefit go to the personnel office. Research assistants whose tuition is paid by payroll deduction proceed directly to the bursar's office. All graduate students must pay their tuition bills either in person or by mail at the bursar's office. Receipts will be issued upon request.

Late registration penalties. Registration between the second and tenth day of class during the fall and spring semesters, and the second and fifth day of class during the summer sessions will require a late registration fee. Students who have not completed the registration process by the tenth day of the regular academic semester or by the fifth day of the summer session will not be permitted to attend class.

Services provided by the registrar. In addition to maintaining student academic files, the office of the registrar fills transcript orders. The registrar honors written and over-the-counter requests to have transcripts mailed to schools and prospective employers.

The office also forwards final grades to students approximately two weeks after each final exam period, provided student credentials are in order.

Graduation

Application for degree. Candidates for degrees to be conferred on University Day in May or June must file an application for degree with the registrar by March 1. Candidates for degrees to be conferred on Founder's Day in October must file this form by September 1. Candidates for degrees to be conferred in January must file by December 1. Late application for a degree will incur a penalty fee of $25.

Clearance. Graduate students must receive clearance from the university prior to the awarding of the degree. The following obligations must be satisfied:

- Students must be certain that they have completed all coursework for incompletes they may have received.
- Theses and dissertations must be cleared by the Graduate School office.
- All financial obligations must be cleared with the bursar. Tuition fees, bookstore charges, library fines, and motor vehicle fines must be paid before graduation.
- All library books on loan must be returned.
- Students must turn in their student identification cards at Christmas-Saucon Hall Annex.
- The interdepartmental clearance sheet must be completed. This form requires the signature of the student's department chairperson (except for the College of Education), and the facilities services office before it is submitted to the registrar at least three days prior to graduation.

Tuition

Tuition for the 1986-87 academic year is $5,250 per semester for twelve or more credits. The cost per credit hour is $440. Tuition is expected to increase on a yearly basis. For 1987-88, tuition has been set at $5,700 per semester, or $475 per credit, plus a $200 fee for specified students in engineering and science. Undergraduate students and graduate students may purchase meal plans at the bursar's office. Information may be obtained by contacting the university's food services office.

Tuition payment. Graduate students must register for courses and pay tuition bills at the bursar's office during the registration period held the week before classes begin. Students who mail their registration forms, personal data sheets, and tuition payments to the bursar's office must be certain that their forms are postmarked by the final day of the registration period.

Late payment penalty. Students registering late for classes during the first ten days of the semester will be charged a late registration fee of $25. Students may not register for courses after the tenth day of instruction, which is marked from the first day of classes rather than from the first day a specific course meets.

Tuition refunds. A student in good standing who formally withdraws from a course during the first eight weeks of the semester or reduces the course enrollment below twelve credit hours after the first two weeks is eligible for a tuition refund. The refund schedule for student withdrawals and course adjustments is as follows:

prior to the start of the semester	100%
during first calendar week	80%
during second calendar week	70%
during third calendar week	60%
during fourth calendar week	50%
during fifth calendar week	40%
during sixth calendar week	30%
during seventh calendar week	20%
during eighth calendar week	10%

Students should note that the first calendar week is the week classes begin at the university.

Full-tuition refunds will be granted for registration cancellations or reductions in rosters only when a written notice is presented to the registrar prior to the start of the semester. Cancellation and reduction notifications received after the start of the semester will be recognized based upon the calendar week in which they are received by the registrar. A student suspended or expelled from the university will not be granted a tuition refund.

Tuition and Fees for 1987-88

Full-time students (12 or more credit hours)	**per semester**	**per year**
Tuition	$5,700	$11,400
Per hour charge for credit	475	
Per course charge for audit	475	
$225 tuition grant given to all enrollees in the College of Education and full-time elementary and secondary teachers and administrators enrolled in the three colleges—net cost per credit hour	250	
Research and graduate assistants (charge for 9-10 credit hour semester registration)	3,800	7,600
Maintenance of candidacy	475	
Master's candidate registration fee	475	

Living accommodations. The university maintains a graduate student housing complex in the Saucon Valley that has 112 living units. This complex, Saucon Village Apartments, provides units generally on a yearly lease basis. For the 1987-88 period beginning in September, the following monthly rents exclusive of utilities prevail:

Efficiency apartment	$280
One-bedroom apartment	335
Small two-bedroom apartment	370
Two-bedroom apartment	365
Three-bedroom apartment	370

Other Fees

Applicable to undergraduate and graduate students:	
Application fee (for admission consideration)	$35
Late registration (for completing registration after announced day)	25
Late application for degree	25
Examinations	10
Make-up (after first scheduled make-up)	
Senior re-exam	
Special exam, anticipatory exam	
Late payment (after announced date)	25
Late processing fee	50
Return check fine	10
Key penalty, Residence halls (non-return)	10
Key duplicate, Residence halls	3
Identification card (replacement)	10
Applicable to graduate students only:	
Language examination	$15
Thesis, microfilming	25
Dissertation, microfilming	50
Copyright fee	25
Placement fee, School of Education	10

Supervision fee, College of Education (per 3 credits)

Counselor intern	100
Counselor and school psychology clinic	100
Social restoration intern	225
Reading practicum	100
Administrative intern	225
Elementary and secondary intern	225
Special education intern	225

Financial Aid

Financial aid for graduate students can be either academic or non-academic. Teaching assistantships, research assistantships, graduate assistantships, fellowships, and scholarships are academic awards made by individual academic departments or by the dean of the Graduate School. Several graduate assistantships unrelated to a particular area of study can be obtained by applying to administrative offices. Finally, loans and work-study employment are distributed by the office of financial aid.

Academic awards. Applications for fellowships, scholarships, research assistantships, teaching assistantships, and graduate assistantships to begin in the fall term must be filed with academic departments no later than February 1 of the preceding year. After completing the standard application form, students should check their departments for a list of specific requirements governing the distribution of awards. Generally, a special committee formed by department faculty selects the recipients of these awards based upon merit; students are not required to submit a financial statement.

In addition to their stipends, teaching assistants will receive a tuition award. Fellowship holders also receive a tuition award plus a stipend. Scholarship recipients are awarded tuition. Research assistants will also receive a stipend, but their tuition is handled by payroll deduction and their registering department. University employees may register for at most two courses per semester with appropriate approval.

Teaching assistants and graduate assistants. Teaching assistant and graduate assistant (T.A./G.A.) are technical terms used to describe specific types of Lehigh University student employees. The duties of T.A.s and G.A.s are generally set by the departments or offices which employ them, but certain conditions must be satisifed before a student can be classified as a teaching assistant or a graduate assistant. These include:

- Each T.A./G.A. must have regular graduate student status and must be a full-time resident Lehigh graduate student, which normally requires registration for at least nine credit hours per semester. (Students on maintenance of candidacy may be considered full-time.)
- A T.A./G.A. is a half-time position and each T.A./G.A. provides services to Lehigh University of up to twenty hours per week.
- Each T.A./G.A. must be paid a specific stipend that is set for the academic year by the dean of the Graduate School after consultation with the director of the office of research and the director of budget.
- Each T.A./G.A. receives tuition remission for at most ten credit hours in a regular semester. No T.A./G.A. may register for more than ten credit hours. Quarter-time and eighth-time T.A./G.A. appointments are possible for full-time resident graduate students with stipends and tuition remission appropriately reduced. No other fractional T.A./G.A. appointments are permitted.
- Each T.A./G.A. is appointed by a process that begins with a formal letter of appointment issued by the appropriate department chairperson. The appointment letter specifies standard university conditions including stipend level, time of arrival, length of service, and the requirement of satisfactory academic progress and performance of duties. Each department chairperson submits written notification of T.A./G.A. appointments to the appropriate college dean or vice president. Normally, this is accomplished through the use of the appointment/assignment form.

The graduate committee endorsed academic guidelines for new teaching assistants that exceed minimum admission requirements. Each T.A. should satisfy one of the following: have a G.P.A. of 3.0 or better in the undergraduate major field of study; have a G.P.A. of 3.5 in the senior year major field; rank in the 85th percentile or higher on the Graduate Record Exam or other standardized test; or have a G.P.A. of 3.5 in at least twelve hours of graduate work in the major field.

In addition, each teaching assistant must make normal progress toward a graduate degree. The definition of normal progress may vary among departments, but the criteria for satisfactory progress are established by the department faculty and the graduate committee. Teaching assistants who fail to satisfy these criteria are ineligible for reappointment.

Teaching assistants whose native language is not English must, in addition to taking the TOEFL examination, submit scores received on the Educational Testing Service's Test of Spoken English. In addition, these teaching assistants are required to take the SPEAK examination, administered by Lehigh University.

- Tuition remission for T.A.s/G.A.s is authorized by the appropriate dean or vice president as part of the registration process.
- Each college dean or appropriate vice president will be provided tuition remission accounts against which T.A./G.A. remissions will be charged. The accounts will be budgeted at an amount equal to the ten-hour T.A./G.A. tuition rate times the approved number of T.A./G.A. positions included in the annual operating budget. The budgets shall not be exceeded. If additional T.A./G.A. positions are desired on a temporary basis, the account executive must provide for the transfer of budget support to the remission account. These budgets are to be used exclusively for tuition remission for authorized T.A./G.A. positions.

There are a limited number of summer T.A./G.A. appointments. These T.A./G.A. employees must receive the same monthly stipend as academic year T.A./G.A. employees and must provide services of up to twenty hours per week to the university. Ordinarily, a summer T.A./G.A. registers for exactly three credit hours in each summer session of employment and receives tuition remission for that registration. In no case may a summer T.A./G.A. register for more than three credit hours in a summer session of employment. The appointment procedures for summer T.A./G.A.s are the same as those for academic year T.A.s/G.A.s

A student who is a T.A./G.A. for a complete academic year is entitled to at most three hours of thesis, research, or dissertation registration (not course credit) in the following summer without payment of tuition.

Research assistantships. Assistantships for research (R.A.s) on various sponsored research projects are available through academic departments and research centers. Information is available from department chairpersons and from center directors.

Non-academic graduate assistantships. Graduate students may apply directly to administrative offices for graduate assistantships unrelated to their areas of study. The availability of these assistantships is based upon the needs of the individual departments. Graduate assistants are employed regularly by the Graduate School office, the office of the vice president and dean of student affairs, the dean of students office, the office of counseling and testing services, and the office of career planning and placement services.

Loans and work-study awards. Students may apply for Carl Perkins (National Direct Student) Loans (NDSL), Lehigh University Tuition Loans (UTL), and College Work-Study (CWS) through the office of financial aid, located at 216-218 West Packer Ave. These aid sources are awarded on the basis of financial need as determined by the Financial Aid Form. The FAF and the Lehigh application must be accompanied by the most recent copy of both the student's federal tax return as well as that of his or her parents. Financial Aid Transcripts (FAT) are required from all post-secondary institutions attended before (1) funds may be disbursed or, in the case of GSL and PLUS loans, (2) applications can be certified. This is a federal requirement.

Carl Perkins (National Direct Student) Loans may be awarded in amounts up to $4,500 for an academic year to full-time students (nine or more hours per semester). Interest

is at 5 percent per annum, with quarterly repayments commencing nine months after graduation or withdrawal. Total NDSL borrowing cannot exceed $18,000 for both undergraduate and graduate study. Information on deferment and cancellation provisions is detailed in the catalog section concerning undergraduate financial aid.

University tuition loans may be awarded in amounts up to one-half the tuition paid to the university. Interest rate is subject to change; contact the office for the current rate. Repayment commences six months after graduation or withdrawal from the university, in monthly installments of $50 plus interest until repaid in full.

College work-study, subject to the availability of funds, may be awarded to graduate students. The university pays on an hourly rate basis. All sources of aid, including CWS, cannot exceed the student's computed financial need.

Frank Brady loans are made from an endowed fund that permits loans of up to $2,500 to be awarded to students enrolled in the MBA program. Applications are filed initially with the department of accounting. Subject to the approval of the chairperson of that department, the applicant completes the final application with the office of financial aid. Brady loans are made without regard to financial need. Interest rates are subject to change. Contact the office of financial aid for the current rate.

U.S. Steel loans are administered by the dean of the Graduate School. Loans of up to $2,500 may be requested, with interest at the rate of two percent per annum. Repayment of the principal will be at the rate of $1,000 per year or 25 percent of the loan, whichever is less. The installment and interest will be paid on each anniversary of the student's termination of residency. Loans may be awarded to qualified graduate students in the College of Engineering and Applied Science or the College of Business and Economics. Financial need, as determined by the dean, is a prerequisite for consideration.

Guaranteed student loans (GSL) are granted by commercial lenders. Students may borrow up to $7,500 per year of full-time enrollment (or $3,750 for half to three-quarter time enrollment). All borrowers must file a financial aid form (FAF) to determine eligibility. FAFs are available from the office of financial aid. Factors that affect eligibility are income level, cost of attendance, level of enrollment and the amount of any other aid received. Detailed brochures are available in the office of financial aid or at participating lenders. Students who borrowed as undergraduates should continue to borrow from their previous lender. Interest is currently 8 percent per annum through the first four years of repayment, increasing to 10 percent for the remaining repayment years. Repayment commences six months after graduation or less than half-time enrollment. The lender deducts a 5 percent loan origination fee from the proceeds of the loan.

Supplemental Loans for Students, formerly **ALAS,** are available on a non-need basis to supplement any of the above, so long as all aid sources do not exceed the cost of education. Annual loan limits are $4,000 for full-time students and $2,000 for half-time students. Eligibility is based on a good credit rating and the ability to repay the loan. A financial endorser may be required.

A student's official classification with the registrar governs the way in which the loan coordinator for the office of financial aid must certify loan applications. For GSL purposes, an associate graduate does not qualify to borrow at the graduate student rate of $7,500 per year for full-time study. An associate student is limited to $4,500 for full-time study and $2,250 for half-time enrollment, further affected by whether or not he or she received a loan as a fifth-year undergraduate. Questions may be directed to the coordinator in the financial aid office.

Degree Information

The following degrees are offered by the Graduate School: the master's degree, the doctor of philosophy, and the doctor of arts.

Master's Degree

Candidates for the master's degree have six years in which to complete their programs. Students should confer with their program advisers to be certain that their departments' specific course requirements are met. The following requirements must be satisfied by master's candidates in all departments.

Course requirements. A student's program must include: not less than thirty semester hours of graduate work; not less than eighteen hours of 400-level coursework; and not less than eighteen hours of coursework in the major of which fifteen hours must be at the 400-level. All coursework for the master's degree must be taken under at least two instructors and must normally be done in attendance at Lehigh University. With the approval of the graduate committee, a maximum of six credits may be transferred to a Lehigh master's program.

Minimum academic standards. Pass-fail registration for graduate students is not permitted. A student may receive no more than four grades below B− in courses numbered 200 or higher in order to continue graduate study. Grades of D+ and lower may not be counted toward a graduate degree.

Incompletes. Graduate students are permitted one calendar year to remove incomplete course grades unless an earlier deadline is specified by the instructor. Incompletes that are not removed by the deadline remain N grades on the record, and the student does not receive credit for the course. Thesis or research project N grades may remain beyond the one-year deadline until work is completed.

Course withdrawals. A withdrawal from a course within the first ten days of classes is not recorded on the student's record. A student who wishes to withdraw from a course after the tenth day, but not after the ninth week of instruction, receives a grade of W. A student who withdraws after the ninth-week period will receive a "WF" or "WP" at the discretion of the instruction. A student withdrawing from a course submits a department approved change of roster form to the Graduate School office.

Program for the master's degree. A student must complete a typed program of courses proposed to satisfy the degree requirements. This form should be submitted to the department chairperson and then to the graduate committee for approval as soon as possible after fifteen credit hours toward the degree have been completed. Approval of the program by the graduate committee signifies that the student has been formally admitted to candidacy for the master's degree.

Thesis and comprehensive exam. Candidates are required to submit a thesis or a report based on a research course of at least three credit hours, or to pass a comprehensive examination given by the major department. The department will specify which of these requirements applies and may require both. If required, the thesis or report shall not count for more than six credit hours. University procedures must be followed if the thesis or research project involves human subjects. One unbound typescript of the thesis, including an abstract and approved by the thesis adviser, must be delivered to the dean of the Graduate School at least three weeks before the degree is conferred. A binding and microfilming fee of $25 must be paid to the bursar. The student must present the bursar's receipt for payment with the completed thesis to the dean. A list of specific guidelines stipulating the form of the thesis is available in the Graduate School office.

The student must be registered in the semester in which the degree is conferred. (A spring or summer registration will satisfy the registration requirement for the following Founder's Day degree.)

Doctor of Philosophy

Time and tuition requirements. A candidate for the doctor of philosophy degree is expected to devote at least three academic years to graduate work. All post-baccalaureate work toward the doctorate must be completed within ten years. A student beginning Ph.D. coursework after an elapsed period of at least one semester after the master's degree has been conferred is granted seven years in which to complete the doctoral program.

Doctoral students must pay tuition equivalent to three full years (ninety credit hours) beyond the bachelor's degree or two full years (sixty credit hours) beyond the master's degree. However, resident students who during their entire doctoral program, including the semester of graduation, have paid full tuition continuously (normally a minimum of nine credit hours per academic semester) will have satisfied the tuition requirements for the doctoral degree upon completion of all other degree requirements. After admission to doctoral candidacy (see section on admission to candidacy), a student must maintain continuous registration by registering at least two times each calendar year (each academic semester or in one academic semester and one summer session). Until the tuition requirements are met, a doctoral candidate must register for a minimum of three credit hours two times each calendar year. After these fees are met, the minimum allowable registration for doctoral candidates is maintenance of candidacy (tuition equivalent to one credit hour) two times a year. Please note that the continuous registration stipulation requires doctoral students to be registered in the semester they receive their degrees.

Academic standards and grades of incomplete. Minimum academic standards for Ph.D. coursework and the policy governing the removal of incomplete grades are the same as those specified for the master's degree. (A doctoral student may accumulate no more than four grades below B− in his or her entire Lehigh graduate career.)

Residence. Each Ph.D. candidate must satisfy Lehigh's residence requirement. The residence requirement is intended to ensure that doctoral students spend a period of concentrated study and intellectual association with other scholars. Either two semesters of full-time graduate study or 24 credit hours of graduate study within a twelve-month period must be completed.

Individual departments may impose additional stipulations. Candidates should check with their advisers to be certain that they have satisfied their residence requirements.

Language requirements. Language requirements for the Ph.D. are the option of and in the jurisdiction of the candidate's department. Since proficiency in a language is not a university requirement, each department decides which languages, if any, constitute part of the doctoral program.

Qualifiers. Many departments require students who wish to enroll in doctoral programs to pass qualifying examinations. Since these examinations vary among departments, students should ask their advisers or department chairpersons for more detailed information. If a qualifying examination is not used, students should find out how and when eligibility to pursue doctoral studies is determined.

Admission to candidacy. With the help of an academic adviser, the student names the faculty members of the doctoral committee, a special committee formed to guide the student through the doctoral program. The committee is responsible for assisting the student in formulating a course of study, satisfying specific departmental requirements, preparing for final examinations, submitting a suitable dissertation proposal, overseeing progress in research, and evaluating the completed dissertation. At least four faculty members are appointed to the committee; one must be a member of an outside department. Committee membership must be approved by the university's graduate committee.

A doctoral student should apply for candidacy no later than one year after completion of the master's degree or its equivalent and after passing qualifying examinations if they are required by the major department. The prospective Ph.D. candidate must submit to the doctoral committee a written program proposal that includes a discussion of proposed dissertation research. Upon receiving approval of the proposal, the candidate may then submit the proposal, via the dean of the Graduate School, to the university's graduate committee for formal acceptance to candidacy for the degree. The dean will advise the student of the graduate committee's decision.

If the dissertation research involves human subjects, university procedures must be followed.

Maintenance of candidacy. When tuition fee obligations have been met, students may maintain their doctoral candidacy by registering for maintenance of candidacy in each academic semester or in one academic semester and one summer session until the degree is awarded.

General examinations. Examinations composed and administered by the members of the student's doctoral committee are designed to test the candidate's proficiency in a particular field of study. These examinations, which may be both written and oral, should be passed at least seven months before the degree is to be conferred. If a student fails the general examination, a second examination will be scheduled not earlier than five months after the first. If the results of the second examination are unsatisfactory, no additional examination is scheduled.

Dissertation and defense. The Ph.D. candidate is required to write a dissertation prepared under the direction of a professor in his or her department. The paper must treat a topic related to the candidate's specialty in the major subject, show the results of original research, provide evidence of high scholarship, and make a significant contribution to knowledge in the field.

Upon approval of the advising professor and, if required by the department, secondary readers, the dissertation is submitted to the dean of the Graduate School for inspection at least six weeks before the degree is to be conferred. Upon its return, the student should distribute copies of the paper to the members of the departmental doctoral committee for review and for suggestions for revision. The candidate then schedules a dissertation defense before the doctoral committee, additional faculty members the department may add to the examining committee, and the general public. The date of the examination is sent in advance to the dean of the Graduate School.

After the dissertation has been defended and revised accordingly, the student must submit the final draft of the paper to the dean of the Graduate School for review by the university's graduate committee no later than two weeks before the degree is to be conferred. Two unbound copies must be delivered to the Graduate School office. (One unbound copy must bear the original signatures of the special committee members.) In addition, the candidate must pay a microfilming fee of $50 and present a bursar's recept for the payment.

A list of specific guidelines stipulating the standard form of the dissertation is available in the Graduate School office.

Doctor of Arts (D.A.)

The doctor of arts degree (D.A.) is offered to students preparing for careers in college teaching in the field of chemistry. The program requirements are similar to those for the Ph.D. with the following exceptions: a broader distribution of graduate courses in the field; a minor area of study for students interested in bidisciplinary preparation for two-year college teaching; coursework and training in interpersonal awareness; a supervised internship in college teaching; and a research project appropriate to college teaching in the student's field of specialization.

Postdoctoral Study

A selected number of students who have completed the doctorate may participate in postdoctoral individualized study under the guidance of selected members of the university faculty. Postdoctoral programs foster broad educational and research development at advanced levels and provide opportunities to prepare for specific positions.

Graduate Degrees in Business Administration and Economics

Candidates for admission to graduate study in the College of Business and Economics must provide the results obtained in either the Graduate Management Admission Test (GMAT) for degrees in business administration, or the Graduate Record Examination general test (GRE) and the subject test in economics for degrees in economics.

Master of Business Administration

The Master of Business Administration (MBA) degree program is designed to provide candidates with conceptual, analytical, and operational skills that are involved in the decision-making processes connected with managing human, physical, and financial resources. The MBA curriculum provides a blend of strong theoretical foundation together with practical application in the areas of accounting, behavioral aspects, economics, finance, the legal environment, management, marketing, and quantitative methods.

Education in the business professions requires understanding the various organizational functions and integrating these with internal and external aspects of the enterprise into the managerial process. The program encompasses generalized managerial competence, while permitting advanced concentration in such fields of specialization as finance, marketing, quantitative and behavioral facets of management, accountancy, economics, international trade and finance, and labor and industrial relations.

All candidates for entry into the MBA program are required to take the Graduate Management Admission Test (GMAT). Information concerning this test may be obtained at college and university counseling centers, or by contacting GMAT, Educational Testing Service, CN 6101, Princeton, N.J. 08541-6101.

Program prerequisites. Students entering the MBA program should have completed college-level coursework in principles of economics, calculus, and computer programming. Although failure to complete these prerequisites will not necessarily result in denial of admission to the program, a student without them will be expected to complete the three prerequisites at Lehigh or elsewhere by the end of the first semester following matriculation into the program. If a student can demonstrate proficiency in a high-level programming language without formal coursework, he or she may petition to have the computer programming prerequisite waived.

The MBA curriculum. The minimum number of credit hours required for the MBA degree is thirty, normally consisting of ten courses. This minimum presumes that the several foundation courses in the various functional fields were completed prior to entry into the MBA program. A person who received a baccalaureate degree in business administration from an accredited institution may reasonable expect to have fulfilled these foundation course requirements, (discussed in further detail below). This thirty-hour program can be completed in two semesters by taking fifteen credit hours each term, or by taking twelve credit hours each semester plus six during the summer sessions, or some other combination. The following four courses are required in this format:

Acct 421	Information Systems for Managers
Econ 421	Managerial Economics
Mgt 423	Operations Management
Mgt 429	Managerial Policy and Decision-Making

In addition, six 400-level elective courses are to be selected from at least three functional areas, with no more than three courses being taken toward the degree in any single area. A maximum of two of these six electives may be taken in academic departments at Lehigh outside the College of Business and Economics with prior permission of the MBA director and respective department chairperson. These other departments include (among others) Computer Science, Industrial Engineering, Psychology, and Social Relations.

For the candidate who has not completed one or more of the following ten foundation courses, up to a maximum of sixty credit hours is required in the MBA program—composed of the thirty hours of coursework mentioned above, plus thirty hours (or ten courses) of foundation coursework. However, up to six of these courses may be waived outright upon the candidate providing evidence of satisfactory completion of equivalent coursework, or passing a proficiency examination in that subject area. In addition, four courses are subject to limited waiver, with advanced courses being required as replacement-electives. The ten foundation courses and the waiver policies are:

Acct 403	Financial Flows and Accounting Measurements*
Acct 413	Managerial Accounting and Decision-Making**
Econ 401	Basic Statistics for Business and Economics*
Econ 405	Microeconomic Theory*
Econ 409	Money, Banking, and Macroeconomic Analysis*
Fin 411	Financial Management**
Law 404	Legal Environment of Management*
Mgt 401	Quantitative Methods in Business and Economics*
Mgt 413	Organizational Behavior**
Mkt 413	Marketing Management**

* Waiver policy: This course may be waived if a comparable course or courses (see course description) was taken with a grade of B− or better being earned not more than eight years prior to matriculation into Lehigh's MBA program.
** Limited waiver policy: This course may be waived depending on prior coursework and academic performance as determined on a case-by-case basis in consultation with the MBA director and respective department chairperson in accordance with guidelines established by the faculty. If the course is waived, an advanced graduate-level course in the same area may be required to be taken as one of the six MBA elective courses.

Master of Arts and Master of Science Degrees in Business and Economics

The master of arts and master of science degrees are offered to students interested in pursuing graduate work in economics or in economics and business.

A minimum of thirty semester hours of coursework is required. At least eighteen of these hours must be taken in the College of Business and Economics. In addition, the student will be expected to pass comprehensive examinations in general economic theory and in one other field in the college.

To qualify for the master of science degree, the student must also take Eco. 352, Advanced Statistical Methods, and Management 401, Quantitative Methods, as part of his or her thirty semester hours of coursework.

Master of Science Degree in Management Science

The master of science in the management science program is directed toward integrating the scientific method with the functional aspects of organizations. By investigating the application of quantitative methodology and systems analysis in the context of such areas as accounting, applied economics, finance, marketing, production, and public service, the program helps to develop a meaningful analytical perspective of business problems.

This integration provides the student with a broader perspective of managerial decision making in private enterprise and/or public administration. Students who have had prior exposure as undergraduates to engineering, business, economics, mathematics, or the physical sciences and who desire a quantitatively oriented business program are ideal candidates.

Management science graduates may pursue careers as staff specialists or as line managers who must deal with the increasingly complex problems of industrial, commercial, and public service organizations.

At the completion of the degree requirements, the student will have acquired an excellent background in the various functional areas of business and economics. Included is a three-credit research project or practicum aimed at providing the student with professional exposure while still in a formal educational environment. Each student conducts an empirical investigation of an actual management problem and submits an individual written report.

Doctor of Philosophy

The Ph.D. degree in business and economics is designed to provide advanced knowledge and the capacity to carry on independent research in various areas of business and economics. Holders of the Ph.D. are normally employed in academic positions in departments of economics or in schools of business administration, or in policy analysis and research positions in banks, business, government, and research organizations. Employment opportunities are excellent for holders of this degree.

The Ph.D. program requires a minimum of sixty semester hours of study (including dissertation) beyond the master's degree or ninety hours of study beyond the bachelor's degree. Each student is expected to choose three major and two minor fields of specialized study. Economic theory must be included as one of the major fields. Each student must take a research core of twelve hours and prepare for written and oral comprehensive examinations in the major fields. The chairperson of the doctoral committee will help to arrange a plan of study suitable for each student's program and to prepare the student to pass the examinations.

Major and minor fields of specialization that are normally available include economic theory, international economics, labor economics, managerial economics, money and banking, private finance, and public finance. Minor fields include accounting, marketing, organizational theory, business law, and other related areas in the college or university.

Under the guidance of a dissertation chairperson and committee formed after passing of the examinations, the candidate undertakes research culminating in an acceptable dissertation. The Ph.D. is awarded upon the successful completion of the doctoral dissertation and its oral defense.

Graduate Degrees in Education

Lehigh's College of Education operates as a separate school within the university and offers only graduate degree programs. Students enrolled in the College of Education should check with their adviser for a list of regulations and requirements governing their degree programs.

Registration and tuition. The College of Education does not require pre-registration. Graduate registration is held the week before classes begin. Most students registering for education courses are awarded an education grant that reduces the per credit tuition cost by nearly 50 percent.

Financial assistance. The College of Education, because it does not offer many undergraduate courses, cannot provide teaching assistantships for graduate students. Graduate assistantships and research assistantships are available in the College and in various administrative offices on campus. In addition, graduate students may be recommended for a limited number of fellowships and scholarships, which are awarded by the dean of the Graduate School.

Lehigh's Centennial School, a laboratory school for socially and emotionally disturbed children, provides employment for some Lehigh education students. Graduate students may apply for teaching internships, which pay tuition plus salaries.

Master of Education (M.Ed.)

This degree is offered in the following professional specializations: elementary education, secondary education, special education, educational administration, community counseling, elementary and secondary school counseling, reading, and social restoration. Degree requirements vary from program to program.

Master of Arts (M.A.)

The master of arts degree offered in the field of secondary education provides a major in education with an academic specialty. The student must take eighteen credits of graduate work in education plus twelve credits of graduate work in an academic field. The academic fields that cooperate with the College of Education in offering this program include: classical languages, modern foreign languages, English, mathematics, economics, government, social relations, history, international relations, and physical and natural sciences.

Master of Science (M.S.)

The master of science degree is awarded in educational technology.

Educational Specialist (Ed.S.)

Specialized post-master's terminal degree programs for practitioners are available in school psychology, special education, and various programs for supervisors.

Certification and Concentration Programs

In addition to offering master's degrees, the College offers state certifications in various professional specialties. The College of Education also offers special twelve to fifteen credit programs that provide concentrations in gifted education, and education of the severely/multiply handicapped.

Doctor of Education (Ed.D.)

The doctor of education degree program provides specialized study in elementary education, special education, educational administration, counseling, reading, foundations of education, and educational technology. Successful professional experience is required for admission to candidacy for this degree in most programs.

The requirements for the Ed.D. degree parallel those already stated for the Ph.D. degree with the following exceptions: language examinations are not required; and a statistic's competency examination is required. The residence requirement for the Ed.D. is the same as that for the Ph.D.

Doctor of Philosophy (Ph.D.)

The College of Education also offers the Ph.D. degree to students enrolled in the fields of psychoeducational studies and counseling psychology.

Graduate Study for Engineering Professionals

All departments within the College of Engineering and Applied Sciences offer a cooperative program that allows an engineer working in industry to further his or her education while retaining a professional position. Students enrolled in this program may pursue an M.S., M.Eng., or Ph.D. at Lehigh while employed full-time, completing the course requirements for the degree in a period of time that does not greatly exceed that spend by full-time graduate students in residence at Lehigh.

A professional interested in participating in this program applies to the Graduate School through a participating department. (See course listing for each department for specific areas of research, courses available, and departmental requirements.) When accepted, he or she chooses the track best suited to his or her individual needs. Each track allows a student to obtain a master's degree; then, a highly motivated professional may pursue a doctoral degree if he or she chooses.

In any case, however, the residency requirements for the master's degree are fulfilled by spending two semesters at Lehigh as a resident graduate student. During the intervening semesters or summers, the student returns to the full-time, professional position. (It is best to spend a fall semester and spring semester on campus to allow maximum flexibility in course selection.)

The thesis or project required for the degree sought is decided upon through mutual consultation among the student, the adviser at Lehigh, and the supervisor in industry. The thesis or project work is begun during the student's first semester at Lehigh with the body of work performed when the student returns to his or her position in industry. Then, the thesis is completed when the student returns to Lehigh.

Each student chooses a faculty member at Lehigh who serves as academic adviser, helps the student select appropriate courses, and oversees the thesis or project work. The student also has a corporate adviser, preferably the person to whom the student reports, or a senior experienced member of the corporate staff. It is hoped that in many cases the interactions among faculty member, corporate adviser, and student/employee will form the basis for a continuing relationship between the university and industry that will allow significant and ongoing research areas to be addressed by a sequence of students seeking advanced degrees.

While enrolled in the program, the student remains an employee of the company or corporation and receives his or her salary as usual. (Lehigh considers that salary a matter to be arranged between the student and the employer.) Students are responsible for the full tuition due the university and are reimbursed by their employers according to company policy. Generally this means that students must make satisfactory progress towards the degree sought and achieve acceptable grades in coursework.

Because the program requires additional work by faculty and staff, the company agrees to donate a sum equal to the university's tuition to the department in which the personnel are enrolled. In addition, companies agree to assist the department in meeting laboratory, computer, and other research costs that accrue during the student's research or project work.

The program is structured to be flexible enough to meet the needs of professional participants; the choice of aproach will depend on the circumstances that pertain to particular industries and to the needs and interests of individual students.

A brochure describing this program in detail is available from the College of Engineering and Applied Science , Packard Laboratory 19, Lehigh University, Bethlehem, Pa. 18015.

Graduate School Organizations

Several organizations within the Graduate School have been organized to deal with educational policies concerning graduate students and faculty and to help graduate students present their ideas, problems, and complaints to the appropriate persons.

Graduate Committee

The graduate committee consists of the dean of the Graduate School and twelve members representing the faculties of Lehigh's colleges: four from the College of Arts and Science; two from the College of Business and Economics; four from the College of Engineering and Applied Science ; and two from the College of Education. In addition, four graduate students from these divisions attend committee meetings as non-voting members.

The committee develops general policies and regulations on graduate education. These are submitted to the faculty for approval.

The committee acts upon course changes and curriculum proposals submitted to it by the faculties of the colleges. These proposals are sent to the educational policy committee for review and submission to the faculty.

The graduate committee interprets graduate educational policies. The committee has independent executive power with regard to graduate petitions. In order to provide a forum for complaints regarding academic and non-academic matters, the graduate committee will schedule hearings for individual graduate students' grievances. Students may petition, via the dean of the Graduate School, for extensions of time to complete degrees and for reinstatement to programs.

Graduate Alumni Committee

The Lehigh University Alumni Association has established a graduate alumni committee. The committee is composed of distinguished Lehigh graduate alumni and is chaired by Robert E. Powell, Ph.D. 1966, who is dean of the Graduate College at Kent State University. The vice chairperson is Michael H. Danjczek, M.Ed. 1974, the director of the Easton Children's Home. The committee will provide leadership deepening the involvement of graduate alumni in Lehigh affairs.

Graduate Student Council

The graduate student council, comprised of one graduate student from each academic department, represents the graduate student community regarding graduate programs and graduate student life at Lehigh. It provides a focus for discussion with university officials and committees. Graduate students selected by the graduate student council are non-voting members of the graduate committee, the educational policy committee, and the research council. In addition, four graduate student council members serve on the dean's advisory committee in order to provide a liaison between the dean of the Graduate School and the graduate student council.

Besides functioning as a forum for discussion, the graduate student council maintains a graduate student center. The council plans social events and disseminates information in order to facilitate communication among graduate students.

Interdisciplinary Graduate Study and Research

In addition to offering graduate degrees within academic departments, Lehigh University offers interdisciplinary graduate degrees in the fields of applied mathematics, polymer science and engineering, molecular biology, physiological chemistry, educational technology, and management science.

The university also affords opportunities for interdisciplinary study in areas of research. Programs in solid-state studies and municipal administration are examples.

In addition, Lehigh's eleven interdisciplinary research centers, nine institutes and two academic centers address the broad-based research needs of government, industry, and the social community. Organized to recognize research efforts in interdisciplinary problem areas, they supplement the university's academic departments. Graduate students pursuing M.S. and Ph.D. degrees in academic departments as well as students enrolled in interdisciplinary degree programs may pursue research opportunities in the various centers.

A complete listing of research centers, institutes, and other research organizations appears following the section on interdisciplinary graduate programs.

Financial assistance. Teaching assistantships and fellowships are provided by individual academic departments, while research assistantships are available through both academic departments and research centers. Students interested in research are encouraged to seek appointments with members of the faculty working in their area of special interest, with department chairpersons, or with center or institute directors.

Interdisciplinary Graduate Programs

Several interdisciplinary programs are offered to the Lehigh graduate student.

Applied Mathematics

The committee on applied mathematics administers interdisciplinary graduate programs leading to the degrees of Master of Science and Doctor of Philosophy in Applied Mathematics. Applications are invited from students with backgrounds in engineering, mathematics, or the sciences. Teaching and research assistantships, university fellowships, and scholarships are available to qualified applicants.

Students must participate in the program either through the division of engineering mathematics within the department of

mechanical engineering and mechanics, or through the division of applied mathematics and statistics within the department of mathematics. Applicants must specify on their application to which of these departments they are applying and designate applied mathematics as their area of specialization.

The division of applied mathematics and statistics is interested in developing theory and methods to solve problems that may be motivated by physical considerations, and in applying mathematics to various areas of science and engineering. For further information, contact Professor Gregory T. McAllister, department of mathematics, Christmas-Saucon Hall 14, Lehigh University, Bethlehem, Pa. 18015.

The division of engineering mathematics is concerned with the application of mathematics to the engineering and physical sciences. Emphasis is placed on the development of efficient methods for the solution of practical and industrial problems. For further information, contact Professor Philip A. Blythe, department of mechanical engineering and mechanics, Packard Laboratory 19, Lehigh University, Bethlehem, Pa. 18015.

Applied Social Research

The applied social research program leads to the Ph.D. degree. The objective is to train specialists to consult on and to conduct applied social science research involving individuals, groups and social settings in business and industry, educational organizations, medical and human services programs, and governmental planning and policy making agencies. The interdisciplinary program is sponsored by the departments of psychology, social relations, and government in the College of Arts and Science, by the College of Business and Economics, by the College of Education and by the Center for Social Research. The training program includes relevant research techniques and strategies from the disciplines these departments and colleges represent.

In recent decades specialized methods have been developed for conducting research involving economic projections, market research, environmental and social impact analyses, experimental research, and program evaluation and to gather data for governmental and private planning and policy analyses. The methods have common features such as research planning, design and implementation, measurement design, sampling procedures, statistical analyses, computer applications and data management, interpretation and evaluation of results, and decision making based on the results.

The aim of the applied social research program is to develop methodological generalists who are knowledgeable in and have experience with the rather wide variety of methods required to conduct research in business, educational, social service, governmental and planning organizations. In contrast to academic settings where the tendency is to become increasingly specialized, the need in applied settings is for expertise in solving problems requiring a variety of social-science research skills. In addition to a broad methodological background, the program provides the student with experience in conceptualizing, designing, implementing, interpreting, and communicating applied research.

Program requirements. Entrance requirements are a master's degree in social science, psychology, education or business, or in a field deemed by the coordinating committee to provide relevant background and sufficient quantitative skills to give some assurance of success in the program. A program of study and research will include courses in statistics, research design, measurement design, computer methods and research applications. A qualifing examination is given after 18-20 credits of work. Advanced courses, a research internship and a dissertation complete the requirements. Specifics of a student's program are to be worked out with a faculty adviser and depend on the student's past experience, educational and occupational goals.

Financial aid. Research assistantships, teaching assistantships, and fellowships or scholarships are available.

Application for admission. Requests for further information and for applications for admission should be directed to: Roy C. Herrenkohl, chairman, Applied Social Research Ph.D. Program Coordinating Committee, Center for Social Research, Lehigh University, 10 W. Fourth St., Bethlehem, Pa. 18015.

Clinical Chemistry

The M.S. program in clinical chemistry is offered by the department of chemistry in cooperation with the Lehigh Valley Hospital Center. It is directed toward training clinical laboratory scientists to be active in hospital-based and industrial laboratories in both patient sample service and new product development. The program requires fulfillment of a clinical laboratory practicum as well as a research project at the M.S. level. The core requirements for the degree are:

Chem 371	Elements of Biochemistry I (3)
Chem 372	Elements of Biochemistry (3)
Chem 332	Analytical Chemistry (3)
Chem 336	Clinical Chemistry (3)
Chem 358	Advanced Organic Chemistry (3)
Chem 437	Pathophysiological Chemistry (3)
Chem 439	Clinical Laboratory Practicum (1 or 6)
Chem 421	Chemistry Research (1-4)

Electives or courses that may be substituted, upon an approved petition, for core requirements in clinical chemistry can be drawn from those listed in the Ph.D. programs in molecular biology or physiological chemistry (see below).

Students may be admitted into this program from undergraduate majors in chemistry, biology, medical technology, or other areas of the biochemical life sciences. One semester of undergraduate physical chemistry is required for the M.S. in clinical chemistry although in some cases this course may be taken while enrolled as a graduate student but for no graduate credit. Graduates of the program are encouraged to continue their education toward the doctorate in any one of the several biological chemistry programs offered at Lehigh.

Educational Technology

The program in educational technology is designed to meet the growing need for trained personnel to effectively utilize microcomputer technology in education and training.

The primary emphasis of the proposed program is to train educators to teach *with* computers. This is in contrast to teaching *about* computers, which implies a computer science and/or a data processing orientation.

The master of science program and post-master's-study instructional technology are designed to admit a limited number of persons interested in developing a strong competence in the utilization of the microcomputer in education and training.

The educational technology program is structured around five primary training goals: to provide a strong technical background in microcomputer software design; to establish a knowledge base of microcomputer hardware/software and allied hardware/software appropriate to instruction and training; to establish a knowledge base of significant research findings in the areas of learning, teaching, training and evaluation; to establish learning experiences appropriate for professional education and training specialists; and to provide opportunities for direct experiences in an education or training environment.

Program requirements. The program requirements for an M.S. consist of the following thirty credit hours of approved graduate study:

Area 1: Microcomputer Programming (9)
EdT 311/CSc 311 and EdT 415 **or**
EdT 313/CSc 11 and EdT 417/CSc 217 **and**
EdT 419/CSc 211

Area 2: Microcomputer Software/Hardware (3)
EdT 421 **or** EdT 425

Area 3: Educational Processes and Theory (6)
AdmS/HD/I&C 403 **and** EdT 335 **or** EdT 435

Area 4: Instructional Applications (3)
EdT 343/CIS 343

Area 5: Directed Field Experience (3)
EdT 493

Area 6: Electives (6)

Management Science

The industrial engineering department, in conjunction with the department of management and marketing, offers an interdisciplinary degree in management science.

The management science program is directed toward integrating the scientific method with the functional aspects of organizations by investigating the application of quantitative methodology and systems analysis in the context of such functional areas as accounting, finance, marketing and production. This integration provides the student with a broader perspective toward managerial decision making in private enterprise and public administration.

Undergraduates with a background in engineering, business, economics, mathematics, or the physical sciences who want a professional career as a staff specialist in management science are appropriate candidates. In addition, those candidates who intend to seek line manager positions find the management science background advantageous in dealing with the complex problems of industrial, commercial, and public service organizations.

The candidate is assumed to have acquired basic competence in the areas of accounting, marketing, corporate finance, production, data processing, microeconomics, linear algebra, calculus, statistics, and introductory operations research.

Required courses

IE 418	Simulation
Mgt 321, IE 334	Organizational Behavior
or Mgt 413	and Structure
Eco 421	Managerial Economics
IE (Mgt) 430	Management Science Project

nine hours of quantitative methods
six hours selected from a functional area

The minimum program consists of thirty hours of approved course work.

Sample program

IE 418	Simulation
Mgt 413	Organization Behavior
IE (Mgt) 430	Management Science Program
Eco 421	Managerial Economics
IE 311	Decision Processes
IE 417	Mathematical Programming
Eco 455	Econometric Models
IE 325	Production Control
Fin 430	Financial Management
Fin 431	Advanced Investment Analysis and Portfolio Management

Manufacturing Systems Engineering

Lehigh's interdisciplinary graduate program leading to the master of science degree in manufacturing systems engineering (MSE) is sponsored by all the engineering departments in the College of Engineering and Applied Sciences. In addition, the College of Business and Economics participates in teaching management and other business aspects of manufacturing systems.

The graduate curriculum in MSE is designed to develop engineers who can design, install, operate, and change manufacturing systems that involve people, machines, new materials, information systems, and appropriate technology. The program integrates systems perspectives with interdisciplinary education and training.

Program requirements. The M.S. program in manufacturing systems engineering is designed as a one-year, full-time program beginning each January. It requires a minimum of 30 credit hours of graduate study. The program is structured as follows:

Spring semester

Required courses:

MSE 421	Managing the Corporate Manufacturing Function (3)
MSE 423	Product Design/Analysis (3)
MSE 425	Production Planning and Resource Allocation (3)
MSE 427	Production Systems (3)

Professional seminars: Two-hour weekly seminars involving MSE topics, literature, minicase studies, and plant trips.

Included summer project work (ten weeks): One-week manufacturing management simulation game designed to teach the importance of information, integration, and cooperation across the traditional organizational lines of a manufacturing company.

Project or thesis option:

MSE 451. Manufacturing Systems Engineering Project (3) Eight-week project work involving the solution of a problem in manufacturing systems engineering. A written report is required.

MSE 490. Manufacturing Systems Engineering Thesis (6) Students will conduct MSE thesis research beginning in the summer. Students will continue their thesis research in the fall semester.

Additional summer project work: One-week study tour visiting selected U.S. manufacturing plants, design centers, and research facilities. Students and faculty will analyze the use of modern MSE-related technology in each of the visited facilities.

Fall semester:

MSE 431	Management, Technology and Business Enterprise (3)
MSE 433	Technology and the Factory of the Future (3)

Professional seminars: Two-hour weekly seminars involving MSE topics, literature, minicase studies, and plant trips.

Elective courses (6 or 9 credit hours): Students are required to take three approved elective courses with the exception of those students continuing their thesis work, who would take only two.

MSE-approved elective courses may be chosen from seven technical and business areas related to manufacturing systems engineering:
—Computer Aided Engineering (CAE)
—Automation and Computer Integrated Manufacturing (CIM)
—Manufacturing Information and Control Systems
—Manufacturing and Work Systems
—Business and Management Aspects of Manufacturing
—Design and Operation of Chemical Processes
—Modern Materials Technology
In addition to the regular classroom work, this program includes extensive use of Lehigh's CAD, CIM, AI, and robotics and manufacturing technology laboratories, as well as a variety of educational features to foster informal learning.

Admission
—A bachelor's degree in engineering or in another appropriate science is required.
—Candidates enroll in the MSE program through one of the university's engineering departments depending on their individual MSE specialization and interests.
—All candidates must follow the admission procedures and standards established by Lehigh University's Graduate School.

—Students enrolling in this program will be both industrial returnees and students with a B.S. degree going straight through college.

Qualified students completing their undergraduate degree requirements by May or June may apply to participate in the work-study internship program described below. Students graduating in December may apply to enroll in the MSE program immediately thereafter.

Industrial internships.* A special work-study internship program has been established as an option for qualified applicants desiring industrial experience before beginning the MSE program in January. A number of these industrial internships are available.

This intern program permits an applicant graduating with a B.S. degree in May or June to work with a participating company in an engineering or related science capacity for six to seven months before entering the MSE program.

Financial aid.* A number of graduate fellowships are available for qualified MSE applicants on a competitive basis.

Special Activities Fee. In addition to the applicable Lehigh University tuition, the MSE Program requires a special activities fee of $2,200 for 1987. Tuition and fees are expected to increase on a yearly basis.

Inquiries. For a brochure describing the MSE program, an application for admission (which includes an application for financial aid), or any additional information, please contact: Roger N. Nagel, director, MSE Program, H.S. Mohler Laboratory 200, Lehigh University, Bethlehem, Pa. 18015. (215) 758-4667.

* Some industrial-internship and financial-aid restrictions may apply to foreign applicants.

Molecular Biology

Graduate study in molecular biology and biochemistry is available within the departments of biology and chemistry and as an interdisciplinary program leading to the M.S. and Ph.D. degrees.

Students are admitted to the departments of biology or chemistry who have appropriate undergraduate preparation in the respective subject, or have backgrounds in molecular biology, biochemistry, or microbiology.

Master's degree requirements. The requirements for the M.S. degree include thirty credits of graduate course work, eighteen of which are at the 400 level, and successful completion of a research project. A written report of the research must be approved by the research adviser.

Required courses

Chem 371	Elements of Biochemistry I (3)
Chem 372	Elements of Biochemistry (3)
Phys 367	Molecular Biophysics (3)
Biol 345	Molecular Genetics (3)
	approved 400-level biology elective (3)
	approved 400-level electives (6)
Chem 479	Biochemical Techniques (3)
Biol 407, 408, or Chem 474, 475	Research (6)

Electives

Students normally select the 400-level biology elective from among the following, although others may be approved.

Biol 416	Immunology
Biol 420	Cellular Mechanisms
Biol 425	Biological Electron Microscopy
Biol 445	Nucleic Acids and Nucleic Acid Complexes
Biol 447	Experimental Molecular Biology
Biol 448	Advanced Molecular Genetics

Additional required 400-level electives and supplementary courses may be selected from the lists below and above.

Biol-Phys 451	Topics in Biophysics (1-3)
Chem 423	Bio-organic Chemistry (3)
Chem 445	Elements of Physical Chemistry (4)
Chem 476	Microbial Biochemistry (3)
Chem 477	Topics in Biochemistry (1-3)
Chem 480	Advanced Biochemical Preparations (1-3)
Biol 325	Topics in Genetics
Biol 353	Virology
Chem 358	Advanced Organic Chemistry
Chem 395	Colloid and Surface Chemistry
Phys 368	Molecular Biophysics

Doctoral degree requirements. Course requirements for the Ph.D. in molecular biology are determined on an individual basis by the student and the dissertation committee.

Before completing the requirements for the M.S. degree, a student who desires to pursue a Ph.D. takes a qualifying examination, which may be both oral and written. Upon successful completion of this examination (it may be taken no more than twice), the student, in consultation with the research adviser, selects a dissertation committee.

Sometime prior to seven months before finishing the dissertation, the student must pass a general examination administered by the dissertation committee. The material covered in this examination is not limited to material covered in courses or obtained through laboratory experience. The student may be tested on all and any areas of molecular biology.

Upon completion of a draft of the dissertation, the student takes the final examination, which is essentially a defense of the thesis.

Physiological Chemistry

The graduate program in physiological chemistry leads to the M.S. and Ph.D. degrees. This curriculum prepares individuals who want to pursue careers in biomedical research, teaching, or administration, or in some aspect of public health.

Individuals may elect to specialize in one of the following areas: nuclear medicine, medicinal chemistry, chemical and experimental parasitology, invertebrate pathobiology, comparative immunology, and chemical physiology. The core course distribution and selection of electives may be altered to reflect the area of specialization.

Students are enrolled in the department of chemistry and are provided with research space in the laboratories of the university's Center for Health Sciences.

Core Courses

Students select at least six of the following core courses:

Chem 303	Nuclear and Radiochemistry (3)
Chem 336	Clinical Chemistry (3)
Chem 371	Elements of Biochemistry I (3)
Chem 423	Bio-organic Chemistry (3)
Chem 424	Medicinal and Pharmaceutical Chemistry (3)
Chem 479	Biochemical Techniques (3)
Chem 435	Advanced Topics in Clinical Chemistry (3)
Chem 437	Pathophysiological Chemistry (3)
Chem 477	Topics in Biochemistry (1-3)
Phys 367	Molecular Biophysics (3) or any course in statistics

Students, with the consent of their graduate committee members, may petition to substitute equivalent courses for some of the required ones. The substitution must be approved for the student's area of research concentration. In addition, each student selects, with the guidance of the committee, sufficient courses from the following to satisfy the requirements of the Graduate School.

Chem 310	Instrumentation Principles I (3)
Chem 311	Instrumentation Principles II (3)
Chem 358	Advanced Organic Chemistry (3)
Chem 372	Elements of Biochemistry (3)
Chem 421	Chemistry Research (1-4)

Chem 423	Bio-organic Chemistry (3)
Chem 424	Medicinal and Pharmaceutical Chemistry (3)
Chem 441	Chemical Kinetics (3)
Chem 445	Elements of Physical Chemistry (4)
Chem 458	Topics in Organic Chemistry (3)
Chem 476	Microbial Biochemistry (3)
Chem 480	Advanced Biochemical Preparations (1-3)
Chem 481	Chemistry Seminar (1-6)
Biol 133	Invertebrate Zoology (3)
Biol 320	Cell Physiology (3)
Biol 322	Animal Physiology (3)
Biol 353	Virology (3)
Biol 402	Comparative Animal Physiology (3)
Biol 405	Special Topics in Biology (microbiology) (3)
Biol 413	Cytochemistry (3)
Biol 421	Morphogenesis of the Lower Invertebrates
Biol 425	Biological Electron Microscopy (3)
Hist 339	Topics in American Public Health (3)
Hist 340	Topics in American Medicine (3)
IR 472	Special Topics (international public health policies) (3)

Students admitted into this program may have majored in biology, chemistry, animal science, entomology, veterinary science, pharmacy, or some other areas of the life sciences.

All students in the doctor of philosophy program are required to satisfy one foreign language requirement and pass a qualifying examination. The completion of a research project is required of M.S. students. A dissertation is required of Ph.D. candidates.

For further information, contact Ned D. Heindel, Chandler-Ullmann 17, Lehigh University, Bethlehem, Pa. 18015.

Polymer Science and Engineering

Lehigh has a diverse group of faculty members with strong, primary interests in polymer science and engineering. In order to provide better opportunities for courses and research in this interdisciplinary field, activities are coordinated through a polymer program committee, with representatives from the departments of chemistry, chemical engineering, and materials science and engineering, as well as from the Center for Surface and Coatings Research and the Materials Research Center. The committee reports to the chairperson of the department of chemical engineering.

Qualified students with degrees in the above or related fields may pursue graduate studies within an appropriate department. The student's adviser may be in that department, in another department, or in a research center. In this case, the student receives a normal departmental degree, but emphasizes polymer courses and research.

Students also may elect to pursue studies towards an interdepartmental degree in polymer science and engineering. The procedures for this case are summarized below.

M.S. in polymer science and engineering. For the M.S., the student is expected to: obtain a total of thirty credits of graduate work, eighteen at the 400-level and eighteen core credits, and complete a research report to the satisfaction of the faculty adviser, and file it with the polymer program committee.

The usual core courses are:

Chem (ChE) 390	Synthesis and Characterization Lab (3)
ChE (Chem) 393	Physical Polymer Science (3)
Chem (ChE) 394	Organic Polymer Science (3)
ChE (Chem)	400-level polymer course (3)
	Research (6)

Because polymer science and engineering embraces many variations on the common theme of macromolecules, considerable flexibility in course selection should be maintained. If deficiencies exist with respect to other undergraduate courses, additional courses may be required; however, some requirements may be waiver for a student who already has a background in polymer science or engineering.

In addition to the required core courses, at least nine elective credits are required at the 400 level. Typical appropriate courses are:

ChE (Chem) 482	Engineering Behavior of Polymers (3)
Chem (ChE) 483	Emulsion Polymers (3)
ChE (Chem Met) 484	Crystalline Polymers (3)
ChE (Chem) 485	Polymer Blends and Composities (3)
Chem (ChE) 492	Selected Topics in Polymer Science (3)
Mat 334	Electron Microscopy and Microanalysis (4)
ChE 400	Chemical Engineering Thermodynamics (3)
ChE 413	Heterogeneous Catalysis (3)
ChE 428	Rheology (3)
Chem 445	Elements of Physical Chemistry (4)
Chem 497	Topics in Surface Chemistry (3)

Other courses may include thermodynamics, mathematics, mechanics, statistics, kinetics, solid-state, organic chemistry or biochemistry, etc.

Ph.D. in polymer science and engineering. For the Ph.D., the student must satisfactorily complete a qualifying examination in a relevant scientific or engineering discipline administered by the appropriate department, or, in the case of a student with a background primarily in polymers, by the polymer program committee; satisfactorily complete graduate coursework determined in consultation with the thesis committee and as approved by the polymer program committee; satisfactorily complete, prior to completion of the Ph.D. dissertation, a general examination (reflecting the polymer field at large) administered by the polymer program committee; and complete and defend to the satisfaction of the thesis committee a dissertation and also a general knowledge of the field.

The thesis committee consists of the research adviser, at least two members of the program committee, and at least one faculty member who is not a member of the committee; the committee's composition is subject to approval by the polymer program committee and the graduate committee.

For more information, write to John A. Manson, Materials Research Center, Coxe Laboratory 32, Lehigh University, Bethlehem, Pa. 18015.

Sherman Fairchild Center For Solid-State Studies

Several solid-state research programs leading to the M.S. and the Ph.D. degrees are available. The departments of chemistry, materials science and engineering, physics, and two interdisciplinary centers, the Materials Research Center and the Center for Surface and Coatings Research, participate in solid-state activities.

While degrees are granted by academic departments, arrangements may be made for students to carry out their thesis research in either research centers or academic departments, including departments other than their own.

The Sherman Fairchild Foundation has awarded Lehigh a total of $6 million in grants. These have provided: the Sherman Fairchild Laboratory, completed in 1976, a 16,800-square-foot building that now serves as the focal point of solid-state research activities at Lehigh; three endowed professorships, one each in physics, electrical engineering, and chemistry-materials; eight graduate fellowships; ten undergraduate scholarships, and funds for scientific equipment. Major facilities in the Fairchild Laboratory are a 3 mev van de Graaff accelerator producing both electrons and positive ion beams, and an electrical device fabrication laboratory for producing planar silicon-integrated circuits.

The Urban Observatory

The Urban Observatory is a unique and innovative effort to assist city officials in resolving the problems facing them today. It functions as a city center for the administration of research and strives to achieve a program of urban research that balances public officials' need for specific policy alternatives and academicians' desire to focus on and explain the underlying causes of urban problems.

Accomplishing this goal involves promoting interaction and cooperation between city hall and the academic community. The building of the institutional bridges that results from this city-university interaction is the heart of the Urban Observatory concept.

The Allentown Urban Observatory, located in City Hall in Allentown, Pa., works through Lehigh University to conduct a wide range of research on urban problems. Each year the Urban Observatory establishes a research agenda, with its policy board making the final decision on which projects will be carried out. This board consists of university officials as well as elected and administrative city officials.

Projects conducted to date have spanned a wide range of academic fields and university departments. Faculty, graduate students, and in some cases, undergraduates, have been involved in social science projects such as an input-output model of Allentown's economy and a citizen participation study; industrial engineering projects such as productivity studies; civil engineering research such as storm water management modeling; business projects such as creating an accounting and reporting system for Allentown community development funds; and interdisciplinary, urban technology studies such as resource recovery and geocoding.

The Allentown Urban Observatory began as one of ten smaller-city observatories scattered around the country. They were established in 1975 through the efforts of the National League of Cities after their initial program of ten large-city urban observatories had proved a success. Allentown Urban Observatory research projects have been funded by various federal, state and local sources; the original grant from the U.S. Department of Housing and Urban Development was administered by the National League of Cities. Currently, the City of Allentown provides the support for the Urban Observatory.

The fact that the university's involvement with the Allentown Urban Observatory is composed of individual research projects means that this is not a degree program or a center for any one type or area of research. It also means that this program offers a unique opportunity to employ faculty and students in using the city as an interdisciplinary laboratory for testing technologies to solve urban problems.

For additional information, contact Roy C. Herrenkohl, director, Center for Social Research; or Arthur E. King, director, Urban Technology Program, Center for Social Research.

Research Centers and Institutes

Lehigh has developed a number of centers and institutes to provide greater research and academic opportunities for primarily graduate students and faculty. Centers and institutes are generally interdisciplinary and complement the scholarly activities of academic departments and represent scholarship and research based on the expertise and capabilities of a group of faculty members. Frequently, centers relate to the broad-based research needs of government, industry, and the social community.

Biotechnology Research Center

The Biotechnology Research Center was established in 1980 by uniting faculty from the departments of chemical engineering, biology, chemistry, and civil engineering. Its mandates are to encourage interdisciplinary research directed toward understanding, characterizing, and harnessing microorganisms, viruses, plant and animal cells, and enzyme catalysts; to maintain well-equipped state-of-the-art laboratories; to promote intellectual camaraderie and cooperative research among center members.

The center is one of the best-equipped basic and applied biotechnology facilities in the country. In addition to the laboratories of individual members (mainly biochemical and microbiological), the center has a central facility in Homer Laboratories comprising approximately 4,000 square feet. It is well equipped with a variety of bioreactors including batch and continuous bench-top fermentors ranging from 300 cc to 30 liters; pilot-scale fermentation equipment ranging in size from 28 to 250 liters, a 300-liter Vogelbusch Deep-Jet Aeration fermentor, and pilot-scale membrane filtration units along with associated computer control and monitoring systems. The central labooratory also houses an immobilized enzyme pilot-scale reactor system.

The financial mainstay of the center is standard contract research from government funding agencies and private companies. In addition, the Biotechnology Liaison Program encourages private companies to maintain strong ties with the university by supporting, through a single program, proprietary research and nonproprietary fundamental research of general interest. Through the program, member companies gain access to university resources, stay in touch with the current basic research in academe and have the opportunity to influence the direction and emphasis of this work. Center faculty associates and their students benefit by keeping aware of the latest developments and needs of the private sector and by being provided with new research ideas and opportunities. The program also provides a particularly good mechanism for students to learn about industrial goals and practices.

Research activities. In general, center research activities include: basic microbiology and virology including strain selection and development; basic fermentation studies dealing with kinetics, transport phenomena, modeling, automatic control, optimization, and fermentor design; scale up of fermentation process; preliminary plant design; solid substrate fermentation; enzyme engineering; on-line computer control of fermentations; biological treatment of municipal and industrial wastes; recovery and purification of fermentation products; economic studies.

Current research projects include: enzyme immunoassay conjugate synthesis; utilization of A/O sludge; cell fusion as a method of viral attenuation; important yeast enzymes in ethanol biosynthesis; microbial desulfurization of coal; fermentation broth rheology; computer control and monitoring of fermentations; use of recirculation fermentors (e.g., Vogelbusch) for viscous and non-Newtonian fermentation broths; maintenance energy of *Zymomonas mobilis;* extractive fermentation; computer simulation of fermentation plants; power uptake, oxygen transfer rate, and mixing time characteristics of the fermentors; use of fluorometry and IR spectroscopy for monitoring and controlling biological processes; development of cellulolytic bacteria and fungi; and optimization of cellulase production in batch culture.

Educational opportunities. The center welcomes graduate and undergraduate students from any academic department to do degree or nondegree-related research under the direction of faculty associated with the center. Center activities and facilities are diverse and flexible enough to meet the needs of any student interested in aspects of biotechnology ranging from basic microbiology and biochemistry to engineering design. Also, regardless of a student's specific goals, he or she will be immersed in a rich and stimulating environment where there is a high level of intellectual camaraderie and cooperative activity through which each center participant can obtain a good appreciation of a rather large segment of the general area of biotechnology.

Graduate students doing dissertation research in the center receive degrees from existing academic departments. (The center does not grant degrees.) Generally, the student's adviser will be a center faculty associate, although he or she may not be from the student's own department. This affords the

student great flexibility in choosing a research area. Also, the close associations in the center make it easy for the student to obtain guidance from several faculty experts and, when advantageous, to have more than one adviser.

Courses dealing with all areas of biotechnology are offered through the departments of chemical engineering, biology, chemistry, and civil engineering. Most are taught by the center's faculty associates who work together to integrate existing courses and to formulate new ones as the need arises. Also, the broad range of expertise allows for team-teaching of appropriate courses. The center encourages this approach because it makes courses more vibrant, more informative, and more authoritative and helps to stimulate intellectual interaction among the faculty members and among students.

The center sponsors a very active seminar schedule that includes prominent speakers from around the world. It also emphasizes heavily presentations made by faculty and students associated with the center. Seminar topics range from basic microbiology to the design and economics of fermentation plants.

Continuing education is another important educational activity of the center. This component includes, but is not limited to, short courses of various degrees of specificity as well as practical training programs dealing with subjects ranging from basic laboratory skills to the operation of large, computer-coupled fermentors.

For more information about the center's activities and financial assistance for graduate students, write to Arthur E. Humphrey, director, Biotechnology Research Center, Whitaker Laboratory 5, Lehigh University, Bethlehem, Pa. 18015.

Center for Chemical Process Modeling and Control

The Center for Chemical Process Modeling and Control (PMC) is a university-industry cooperative research center performing innovative generic and applied research that addresses the chemical processing industry's needs. Founded in 1985, the center is funded through the membership fees of a consortium of industrial companies.

Fifteen faculty members collaborate in the research and teaching responsibilities of the center. They bring expertise from academic disciplines such as chemical mechanical, industrial and electrical engineering, and such diverse research areas as polymer reaction engineering and biotechnology.

Prior to the establishment of the center, Lehigh faculty members, in collaboration with industrial representatives, assessed the research needs in the area of process modeling and control. This assessment recognized that rapid technological advances are driving engineering toward crossdisciplinary interactions. It identified several trends that have already affected and will continue to affect the chemical, petroleum, petrochemical and biochemical industries in the next decade. These trends have generated the need for an intensified research effort in chemical process modeling and control. They define the research mission of the center.

Membership fees support generic research that focuses on advanced, practical methods and tools that are pertinent to several processing problems. Examples of problems of interest to the center are: effective multivariable process control techniques; distillation control; expert control; batch reactor control; reactor modeling; process simulation, and plant-wide control. Member companies proposd research problems. Their suggestions help define the generic research activities of the center and ensure that the center's research is aimed at solving a class of significant industrial problems.

Research Activities. More than ten generic research projects have been initiated as active projects. These projects, representing major research challenges not fully addressed and resolved in the process control literature, are as follows: design of effective nonlinear controllers for chemical reactors; design of practical multivariable process controllers; design and control of energy-efficient distillation column systems; development of software for dynamic process simulation and control system design; application of fluorometry to the monitoring and control of biological reactions; modeling and control of semi-continuous emulsion reactors; plant-wide control; utilization of Fourier transform infrared (FTIR) spectroscopy for the on-line analysis of fermentations; and expert multivariable controllers.

Some of the other research and educational activities of the center include: week-long short courses in a wide range of areas; progress reports of the research activities that are released to the member companies twice a year; an exchange program in which industrial researchers come to Lehigh University to participate in the research program; and the development of specific contractual research arrangements between member or nonmember firms and center faculty members.

Educational opportunities. Due to its special character and mission, the PMC Research Center offers unique educational opportunities to those students who wish to receive a graduate degree with research specialization in the area of process modeling and control. In recognition of the growing need for an engineering education that cuts across the engineering subdisciplines, the center actively involves faculty and students with varied backgrounds and expertise. Furthermore, with its research and educational activities, the center aims at lessening one of the primar weaknesses in present-day engineering education. This relates to students' inadequate understanding of engineering practice; that is, the understanding of how engineering knowledge is converted by industry into societal goods and services. This goal is served by the center's generic and, most importantly, by applied research activities and by a comprehensive series of graduate and undergraduate courses, invited industrial and academic speakers, and group meetings and seminars.

All Lehigh University control courses are coordinated and crosslisted between the departments of chemical, mechanical, and electrical engineering. Group meetings and seminars are used as a mechanism for the increased transfer of information and ideas among center graduate students and industrial researchers from the member firms. Distinguished academic and industrial reseachers, in the areas of process modeling and control, are invited to Lehigh for extended series of lectures and in-depth discussions of current research topics with the center researchers.

To increase the awareness of undergraduate students to the challenges and rewards of research, the center offers opportunities to participate along with graduate students in research. This also provides graduate students with an opportunity to be a researcher and a teacher/supervisor at the same time.

For additional information about the center, contact Christos Georgakis, director, Center for Chemical Process Modeling and Control, Whitaker Laboratory 5, Lehigh University, Bethlehem, Pa. 18015, (215) 758-4781.

Center for Design and Manufacturing Innovation

The Center for Design and Manufacturing Innovation (CDMI) was established in April, 1984. The center had its origin in Lehigh's CAD/CAM program, a nationally recognized educational program started in 1979 that emphasized computer-aided design and computer-aided manufacturing. Although CAD/CAM is still a central focus of the new CDMI, the scope of the center has increased beyond CAD/CAM to include other areas in design and manufacturing, such as manufacturing technology, process systems engineering, computer-aided construction engineering, robotics, artificial intelligence, and microprocessor applications. Also, whereas the CAD/CAM program was primarily an educational program, the CDMI has both an educational function and a research and development function within its principal activities.

The objectives of the center are: (1) to make Lehigh University a national center of excellence in the application of computers to design and manufacturing systems; (2) to stimulate research in the various areas of design and manufacturing; (3) to foster technology transfer of the knowledge gained through research and development to participating industrial organizations; (4) to promote the most modern and effective uses of interactive computer graphics in engineering education; (5) to enhance laboratory development in appropriate areas related to design and manufacturing; (6) to coordindate campus-wide activities in computer-aided design and computer-aided manufacturing; (7) to provide mechanisms to encourage faculty professional development and student growth; (8) to support the goals and objectives of the Ben Franklin Technology program; and (9) to provide the on-campus focus for the Ben Franklin program efforts in CAD/CAM.

Affiliated laboratories. A number of laboratories and other programs are affiliated with the Center for Design and Manufacturing Innovation. The affiliated labs are listed below:

Computer-Aided Design Laboratory (CAD Lab). This is a laboratory in the department of mechanical engineering and mechanics, devoted to mechanical design. Two VAX 11/780 processors are used to support more than a dozen graphics workstations, including terminals with color and animation capability. An Evans & Sutherland Dynamic Graphics Terminal is also included in the CAD lab. A comprehensive range of software is available for research and instruction, including finite element modeling and analysis, solids modeling, and NC part programming for milling and turning.

Computer-Aided Engineering Laboratory (CAE Lab). This laboratory in the civil engineering department includes a Data General MV 10000 computer to support approximately one dozen graphics workstations. Additional devices include ten standard alphanumeric CRTs, three hardcopy units, and a plotter. A variety of software supports computer-aided problem-solving in civil engineering. The CAE laboratory also serves to complement the experimental testing and reseach facilities of Fritz Engineering Laboratory.

Design and Computing Systems Laboratory. This laboratory in computer science and electrical engineering includes an Applicon 860 CAD interactive computer graphics VLSI Design Center and a Harris 800 computer system. The lab provides opportunities to study novel device-circuit structures that use advanced microelectronics technology and require computer-aided circuit design and computer-assisted characterization and modeling of electronic devices.

Computer-integrated Manufacturing Laboratory (CIM Lab). This industrial engineering department laboratory is equipped with a DEC PDP 11/34 for process monitoring and control and a variety of CAD/CAM systems, including an Applicon 4275 system (with VAX 11/750), and two IBM 4341 processors. More than two dozen graphics and alphanumeric terminals are located in this laboratory for student use. Available software includes solid modeling, VLSI design graphics, NC part programming, and simulation of factory scheduling, robotics, and automated manufacturing systems.

Manufacturing Technology Laboratory. This laboratory in the department of industrial engineering contains conventional and numerical control machine tools for research and instruction in turning, milling, and drilling operations. Instrumentation includes devices for measuring cutting forces, surface finish, tool wear, and related process variables. Experimental data collected in this laboratory can be automatically fed into the PDP 11/34 in the CIM Lab for statistical analysis and reporting. Future enhancements for the Manufacturing Technology Lab include materials handling systems, more CNC machine tools, and flexible automation.

Microprocessor Applications Laboratory. This industrial engineering department laboratory contains a variety of microprocessors, microcomputers, data acquisition systems, and programmable controllers. The purpose of this instructional and research laboratory is to study the problems of interfacing microprocessors and computers to industrial processes for monitoring and control.

Educational programs. The educational program most closely affiliated with the Center for Design and Manufacturing Innovation is the manufacturing systems engineering (MSE) program. The MSE program is a graduate interdisciplinary educational program designed to provide instruction and laboratory experience for engineers who will be planning, installing, and managing production systems in industry. The core curriculum consists of courses in production systems, product design/analysis, production planning and resource allocation, the corporate manufacturing function, technology management, and the factory of the future. Elective courses include a wide variety of subjects in design, automation and production systems, materials, chemical process engineering, information systems, and business.

In addition to the MSE program, other related programs are available in the regular academic departments in the College of Engineering and Applied Sciences.

For more information, write to: Roger N. Nagel, director, Center for Design and Manufacturing Innovation, Lehigh University, H.S. Mohler Laboratory #200, Bethlehem, Pa. 18015.

Center for Economic Education

The Center for Economic Education was established in 1976. It is part of a nationwide network of more than 150 such centers under the guidance of the Joint Council for Economic Education.

For more than a quarter of a century, the Joint Council has been involved in programs to reduce the level of economic illiteracy in the United States. The purpose of Lehigh's center is to increase the quantity and improve the quality of economic education.

Located in Johnson Hall, the center is part of the College of Business and Economics. But it takes on an interdepartmental role as it coordinates programs aimed at heightening understanding of the American business and economic system. The center serves as a clearing house for educational ideas. It also houses an expanding resource library including books, films, filmstrips, curriculum material, testing packets, and stimulation games for use by faculty and area educators.

Research activities. The major goal of the center is not primary research. Still, the center is undertaking need assessment studies to establish priorities for economic education programs. The center is involved in projects to determine effective teaching strategies and testing procedures. In addition to this, the center serves to direct programs which involve faculty in projects designed to explore areas of concern such as energy economics, law and economics, capital formation, etc.

Educational opportunities. An integral part of the center's operation is a summer institute for teachers. The institute is designed to give teachers from all levels the basics of economics as well as assistance in incorporating these concepts into the classroom. The summer institute features courses taught by faculty members and individualized workshop sessions with education specialists. Participants receive college credit for the institute and may enroll in an ongoing summer program leading to the M.A. in economics.

Each semester one or two undergraduates work with the center director on projects ranging from research into the teaching of economics to compilation of information for the publication of a newsletter. Other students are involved in the development of campus-wide economics programs.

The center also sponsors workshops, seminars and guest lectures designed to meet the educational needs of faculty and students. Sessions such as the American Iron and Steel Industry Economic Seminar allow members of the Lehigh community to meet with academic and business leaders to discuss economic issues relating to the industrial process.

For more information, write to the center's director, Warren A. Pillsbury, Center for Economic Education, Johnson Hall 36, Lehigh University, Bethlehem, Pa. 18015.

Center for Health Sciences

The Center for Health Sciences, organized in 1972, is concerned with interdisciplinary research and graduate and postdoctoral training in various aspects of the biomedical sciences and engineering.

The center is comprised of two divisions: the division of biological chemistry and biophysics, and the division of bioengineering. Facilities are provided by these divisions for its members, postdoctoral fellows, and graduate students actively engaged in research in the respective areas.

A large part of the research conducted at the center is supported by private and public agencies and all are related to either basic or applied aspects of problems pertaining to human and animal life.

Research activities. The research opportunities and programs of each division are described below.

Division of biological chemistry and biophysics. Interests currently represented among the thirteen faculty members include the following: immunochemistry applied to clinical diagnostics, modification and use of monoclonal antibodies in radiosensitization and NMR imaging, surface adhesion in biological systems, glycoprotein structure and function, cell-cell interactive proteins, tumor image enhancement, medicinal chemistry, neuroendocrinology, motility and behavior of cells, chemistry of biologically potent molecules, manipulation of bacterial genetics, and recombinant DNA biotechnology.

The administrative offices of the division and most of the laboratories are housed in the Seeley G. Mudd Building. The laboratories are well equipped, and the major pieces of equipment include three NMRs, mass spectrometers, numerous liquid and gas chromatographs, tissue culture laboratory, bacterial transfer room, fermentors, warm room, cold rooms, scintillation and gamma counters, UV-Vis and infrared (including Fourier transform) spectrophotometers, ultracentrifuges and ancillary equipment necessary to conduct the above studies.

This division has an ongoing liaison programs with Hahnemann University and Lehigh Valley Hospital Center; clinical aspects of several research projects are being conducted there.

Division of bioengineering. This unit of the center is concerned with a number of health-related problems that are best resolved by individuals with a background in engineering. Ongoing projects include the study of transport phenomena in the microcirculation, especially capillary-tissue fluid exchange and oxygen transport to tissue; flow in flexible tubes and past constrictions, modeling the venous system and arteriosclerosis; mathematical modeling and experimental studies on the biomechanics of the foot; fracture mechanics of skeletal units, and shock propagation in the human body.

Educational opportunities in the Center for Health Sciences. Graduate students working under the direction of members of various components of the center may satisfy course requirements towards the M.S. and Ph.D. degrees by selecting from the offerings of the departments of chemistry, physics, biology, psychology, civil engineering, mechanical engineering and mechanics, as well as other departments.

In addition, the interdisciplinary graduate program in physiological chemistry leading to the master of science and the doctor of philosophy degrees is supported by the Center for Health Sciences, although all of the students are enrolled in the department of chemistry. Students may also pursue graduate degrees in biochemistry, organic, clinical chemistry, or molecular biology under supervision of center faculty members.

In addition to research, the center sponsors symposia as well as annual series of seminars on topics pertinent to its objectives.

For more information, write to the director, Ned D. Heindel, Chandler-Ullmann Hall 17, Lehigh University, Bethlehem, Pa. 18015.

Center for Innovation Management Studies

The Center for Innovation Management Studies (CIMS) was established in 1984, in response to the needs of industrial executives and government officials for a university-based center to study the management of research and development and technological innovation.

The center's research program is interdisciplinary and involves research associates from several other universities. The center supports studies of the industrial innovation process, encourages publication in the professional literature, and trains students and business executives for technology management responsibilities through regular course offerings and continuing education programs.

The goal of this research is to enhance the contribution of technology to corporate performance and national productivity through an improved understanding of the technological innovation process and its management.

Under the direction of Alden S. Bean, Kenan Professor of management and technology and former director of the division of policy research and analysis at the National Science Foundation, the center is sponsored by 13 corporations, the Ben Franklin Partnership program, and NSF.

For more information, write to Alden S. Bean, director, Center for Innovation Management Studies, Johnson Hall 36, Lehigh University, Bethlehem, Pa. 18015, or call (215) 758-3427.

Center for International Studies

Formed in 1986, the Center for International Studies develops, supports, administers and coordinates internationally oriented programs and activities throughout the University.

The center was established to strengthen the international dimension of Lehigh University by opening new opportunities for students to study and work abroad; by developing new interdisciplinary graduate programs; and by stimulating and supporting research in international affairs. The center offers programs in East Asian Studies, Canadian Studies, Russian Studies and Latin American Studies. In cooperation with the department of international relations, the center organizes the annual Cohen International Lecture Series (1986: Dr. Zbigniew Brzezinski; 1987: Lord Carrington), which was made possible by an endowment established by Bertha and Bernard Cohen ('36). The center also sponsors seminars and guest lectures on international topics. An International Business Institute, as a component of the center, develops curricular and extra-curricular programs oriented to international business and economics.

The center is run by an executive committee representing all four colleges. For more information, write to Z. J. Slouka, director, Center for International Studies, Lehigh University, 215 Maginnes Hall #9, Bethlehem, Pa. 18015. (215) 758-4745.

Center for Social Research

The Center for Social Research is a multidisciplinary organization designed to stimulate and conduct research involving the social and behavioral sciences.

Several disciplines are involved in the activities of the center: economics, political science, psychology, sociology, anthropology, marketing, and international relations. The center also cooperates with the university's other research centers and with several science and engineering departments.

Founded in 1965 as the Center for Business and Economics, the focus of the center was later broadened, and the name changed to the Center for Business, Economics and Urban Studies. The center's early activities included research on economics and business forecasting, and on transportation problems. The change to include urban studies broadened the center's scope to encompass the disciplines of political science, sociology, and history. In 1972, the center's scope was further broadened to include behavioral science and international

affairs, and the present name was selected to more accurately reflect this broadened focus.

Interdisciplinary research. The social perspective of the center's research is interdisciplinary in nature and is relevant to the community outside the university—local, regional, national, and international. Many research activities are based on a cooperative university-community relationship through which the research goals of the center are achieved and community needs met. Interdisciplinary research activities of the center are currently being conducted in the following areas:

Health and Human Development. Members of the departments of psychology, economics, social relations, government, education, environmental biology, and chemistry participate in research on health and human development. The program focuses on life from early childhood to maturity. Research interests include the effect of perinatal loss on families and family members; the influence of family and community on health; management aspects of organizations that serve elderly individuals; public and private pension systems; psychological aspects of aging; design of housing for the elderly, and health and education in later life.

Recently completed projects have examined relationships between apportionment of service agency budgets and agency managerial objectives, inclusion of elderly persons in college courses, reactions of long-term residents to neighborhood change, and a study of cognitive functioning in the later years.

Families and Children. Members of the departments of government, psychology, social relations, and economics participate in the behavorial research program. Research interests include family dynamics and child rearing practices and the emphasis on families included under the health and human development program, particularly the influence of community organization and dynamics on the health of residents. Current research focuses on the effect of family dynamics and child rearing practices on children's development of social competence.

Program evaluation. Members of the departments of social relations, economics, and accounting participate in research to evaluate the effects of a variety of programs. Particular emphasis is on improving program evaluation methodology. Current research interests include evaluation of several business, science and engineering programs in the university. Research has recently been conducted on the effect of compensatory education programs.

Urban technology. The urban technology program includes faculty from several university departments. The primary focus of the program is to provide an integrated, interdisciplinary approach to current urban problems. The program serves as a visible liaison point for both city officials and university researchers. Recently completed research includes energy conservation and cost-reducing methods for local government, storm water management, computer mapping, information systems, vehicle maintenance scheduling, municipal productivity, and program budgeting. Many of these activities began as a part of the Allentown, Pa., Urban Observatory, originally funded by the U.S. Department of Housing and Urban Development through the National League of Cities. The projects are now carried on by the city of Allentown.

Educational opportunities. Master's and doctoral-level degrees are offered through the departments with which CSR cooperates. An interdisciplinary doctoral program in applied social research is offered jointly by the departments of psychology, government and social relations in the College of Arts and Science, by the College of Business and Economics, by the College of Education, and by the Center for Social Research. This program emphasizes training in research methodology relevant in nonacademic settings (see description under Interdisciplinary Graduate Programs).

For more information, write to Roy C. Herrenkohl, director, Center for Social Research, 10 W. Fourth St., Bethlehem, Pa. 18015.

Center for Surface and Coatings Research

The Center for Surface and Coatings Research was established on February 1, 1966. The center has been successful in fostering interdisciplinary research in a broad range of surface-related phenomena including catalysis, corrosion, environment-enhanced cracking in alloys, coatings, dispersions, printing inks, and colloids. Faculty members from the departments of chemistry, chemical engineering, mechanical engineering and mechanics, and materials science and engineering are associated with the center. The center develops and maintains research facilities, including laboratory and office space, and major experimental equipment used in surface-related research. The center facilitates interchanges of ideas and interactions between faculty and students from different disciplines, thereby nurturing research at the forefront of science and broadening the educational opportunities for graduate as well as undergraduate students.

Financial support for the center comes largely from research projects contracts with various industries and governmental agencies.

The center is well equipped with specialty instrumentation needed for advance research in its field. Sinclair Laboratory houses equipment for experimental studies employing flash desorption, Mossbauer spectroscopy, Auger spectroscopy, X-ray photoelectron spectroscopy, electron spectroscopy for chemical analysis, nanosecond fluorescence spectroscopy, ellipsometry, computerized spectrophotometry, microelectrophoresis, and continuous electrophoresis.

Other specialty equipment includes microbalances, testing machines for studies of environment-affected crack growth, gas adsorption and heat of immersion apparatus, wetting balances, apparatus for determining rheological properties, and apparatus for the preparation of reproducible dispersions and films.

Research activities. The center's research program includes a broad range of topics vital to modern science and technology.

Some of the active topics are: solid-state chemistry of catalysts; catalytic oxidation of methane; mechanisms of catalytic reactions and development of new catalysts; wetting of multiphase systems; monodisperse oxides, characterization of surfaces; microelectrophoresis and continuous electrophoresis; electrophoresis under microgravity conditions; computerized color matching; estimation of color differences; color constancy and metamerism in coatings; light scattering in microvoids; Mossbauer spectroscopy of surfaces; erosion and wear, chemical composition of surfaces; passivity and corrosion inhibition; Auger spectroscopy; chemistry of fracture surfaces, hydrogen embrittlement; environmentally affected crack growth; high-temperature corrosion; adhesion of coatings; corrosion under coatings; chemical state of ions in polymers; charge transport through organic coatings; effect of metallic cations on corrosion processes; water-based coating; electrical properties of coatings; polymer surfaces; research in National Printing Ink Research Institute (NPIRI) related to lithographic, flexographic and gravure printing; rheology in non-Newtonian fluids; adhesion and flow of fluids in porous substrates; photovoltaic effects in small particles; and chemistry and metallurgy of galvanized steel.

The JOURNAL OF COLLOID AND INTERFACE SCIENCE and ADVANCES IN COLLOID AND INTERFACE SCIENCES are edited by Albert C. Zettlemoyer, university distinguished professor of chemistry.

Educational opportunities. The center is a facility in which graduate students undertake dissertation research leading to the M.S. or Ph.D. degrees in existing science and engineering curricula. Pertinent courses are offered in the departments of chemistry, chemical engineering, physics, mathematics, biology, materials science and engineering, and mechanical engineering and mechanics.

Potential and current graduate students whose interests are consistent with the center's objectives are welcome to associate with the research program and to avail themselves of the experimental facilities. Research assistantships are available. Since research topics are selected by mutual agreement,

interested students are encouraged to explore research opportunities with the center's director.

The center's research also forms the basis of continuing educational programs designed primarily for industrial personnel. The conference center in Sinclair Laboratory accommodates the special seminars and short courses that are held periodically. Recent course topics include corrosion, printing ink technology, computer formulation of colorants, and paint removal.

The center provides opportunities for resident postdoctoral studies and for visiting scientists.

For more information, write to the director, Gary W. Simmons, Sinclair Laboratory 7, Lehigh University, Bethlehem, Pa. 18015.

Center for the Application of Mathematics

The Center for the Application of Mathematics was established in 1965 to foster interdisciplinary research related to the application of mathematics, to draw on other disciplines for pertinent mathematical problems, and to encourage the development of advanced courses in the application of mathematics. There are currently research programs in the area of nonlinear continuum mechanics, the propagation of waves in nonlinear media, the study of thermally driven flows, variational calculus, numerical analysis, biomechanics, and the application of group-theoretic methods.

For more information, write to the center's director, Gerald F. Smith, Linderman Library 30, Lehigh University, Bethlehem, Pa. 18015.

Emulsion Polymers Institute

The Emulsion Polymers Institute, established in 1975, provides a focus for graduate education and research in polymer colloids. Formation of the institute constituted formal recognition of an activity that had grown steadily since the late 1960s.

The institute has close ties with polymer and surface scientists in the Center for Surface and Coatings Research and the Materials Research Center and the departments of chemical engineering and chemistry.

Polymer colloids or polymer latexes, as they are more commonly called, are finely divided polymer particles that are usually dispersed in an aqueous medium. Important products produced and utilized in latex form include synthetic rubber, latex paint, adhesives and paper coatings. The small particle size of typical latexes make their colloid properties as important as the polymer properties for a number of applications. Hence, the study of emulsion polymers is an interdisciplinary activity.

Research activities. Emulsion polymers research includes a broad range of problems in the areas of preparation, modification, characterization, and application of polymer latexes. Most commercial polymer latexes contain a number of important ingredients; some in only small quantities.

Research programs at Lehigh are aimed at understanding the function of recipe components during preparation and application of the latexes. The research projects are a blend of fundamental and applied efforts as well as a mixture of theoretical and experimental problems: emulsion polymerization kinetics, mechanism and morphology of core/shell latexes, colloidal surface and bulk properties of polymer colloids, polyurethane latexes, mechanism and kinetics of inverse emulsion polymerization, miniemulsions, alkali-swelling behavior of carboxylated latexes, suspension polymerization, NMR studies of polymer colloids, electrophoresis of polymer colloids, rheology of thickened latexes, coating by electrodeposition, and magnetic latex particles.

Significant research support for institute activities is obtained from industrial organizations through their membership in the Emulsion Polymers Liaison Program. Hence some considerable effort is made to relate the research results to industrial needs. Consequently, graduates can find excellent opportunities for employment.

Educational opportunities. Graduate students in the institute undertake dissertation research leading to the master of science or doctor of philosophy degrees in existing science and engineering curricula or in the polymer science and engineering program.

Programs of study for individual students are designed to meet the student's interests, the requirements of the appropriate academic department, and the student's dissertation committee. Considerable flexibility is permitted in the selection of courses and a research topic.

Faculty members of the institute are involved in teaching normal university courses and continuing education courses for industrial personnel. The annual one-week short course, Advances in Emulsion Polymerization and Latex Technology, typically attracts about 100 industrial participants and 20 Lehigh students. This course is an important mechanism for developing meaningful interactions between institute staff and students and industrial scientists and engineers. Educational and research opportunities exist for postdoctoral students and visiting scientists as well as resident graduate students.

For more information, write to John W. Vanderhoff or Mohamed S. El-Aasser, Sinclair Laboratory 7, Lehigh University, Bethlehem, Pa. 18015.

Energy Research Center

Energy research at Lehigh is a multidisciplinary activity, involving faculty and students from engineering, the physical sciences, life sciences, business and economics, and the social sciences. The Energy Research Center provides a structure within which faculty and students from different backgrounds can explore their specific research interests.

The center coordinates the university's energy research, helping the faculty respond to research opportunities and developments in energy. It is also the major contact between the university and industry and government for matters dealing with energy research. Originally founded in 1972 as the Task Force for Energy Research, the center was organized into its present form in 1978.

The research within the center involves a wide range of topics related to the supply and use of energy. Work in progress—supported by contracts and grants from government, industry, and private foundations—deals with fuels and energy resources, energy conversion systems, energy conservation and the environment.

The Energy Research Center has particularly close ties with industry. A number of joint research projects involve Lehigh faculty and students and research staff from industry. The center also operates the Energy Liaison Program, through which participating companies and government facilities have access to faculty consultants, make use of laboratory facilities and library services, and receive assistance on research problems, feasibility studies and other projects related to energy. Through the center's Energy Intern Program, opportunities also exist for students to receive part of their training in industry. Through this program, a graduate student involved in energy can do a research internship in industry under the joint supervision of company research staff and the student's faculty adviser.

Experimental support for energy research is provided in a number of specialized laboratories maintained by the university. These laboratories, furnished with the latest instrumentation and equipment, include the following: boiling and two-phase flow, fluidized bed, fluid mechanics, surface chemistry, chemical kinetics, GC/mass spectrometer, atomic absorption spectrometer, electron optical, mechanical testing, structural testing, welding, metal forming, facture mechanics, ceramics, polymer, hydraulics and water resources, van de Graaff accelerator, biotechnology, aquatic biology, and microprocessor development.

All faculty members who participate in Energy Research Center activities belong to academic departments. In addition, a number of faculty and staff members affiliated with the center have close ties with other on-campus research centers

and institutes, assuring broad interactions between center personnel and experts from many research specialties, including economics, social science, materials and metallurgy, marine biology, fracture and solid mechanics, metal forming, structural design, sanitary and water resources engineering, thermal science, fluid mechanics, surface chemistry, and biotechnology.

Energy research. Research within the center falls within five major categories. Projects of interest include:

Fossil fuels. Fluidized bed combustion of coal; heat transfer in fluidized beds; pulverized coal combustion; catalytic combustion; cyclonic combustion; coal slagging; freezing of coal; coal chemistry; microbial desulfurization of coal; kinetics of coal gasification; fluidized bed gasification; dynamic simulation of coal conversion systems; kinetics of coal liquefaction; hydrogen-enhanced crack growth in high-strength steels; organic coatings for flue gas desulfurization service; weld repair of steam turbine rotors; mechanical properties of cryogenic steels for LNG applications; toughness of pipeline steels; fracture analysis of pipelines; mechanisms of tertiary oil recovery.

Nuclear technology. Instrumentation for reactor safety studies; boiling heat transfer in water-cooled reactors; fracture toughness of reactor steels; static and dynamic fracture toughness of steel welds; microstructural characterization of pressure vessel welds; pressure vessel design, radioactive waste disposal; high-energy particle physics, nuclear physics.

Environmental impact of energy systems. Oil pollution studies in the coastal and wetlands environment; effects of power plant operations on biological life in the New Jersey estuarine region; acid rain; trace metal contamination of aquatic ecosystems; hazardous waste disposal and control.

Conservation and renewable resources. Biological conversion of cellulose to chemicals and fuels; catalysis for alcohols from biomass; energy recovery from municipal solid waste; fuel derived from waste water treatment; energy conservation in the metal-forming industries; instrumentation and analysis of industrial processes; use of computers for process control; development of microprocessors for residential load control; cooling of electric utility generators and high-capacity electric motors; design of cryogenic turbines; instrumentation for HVAC applications; siting of wind-power applications.

Energy economics. Dynamic analysis of energy supply-demand systems; model of an investor-owned electrical utility; peak-load pricing of electricity and natural gas.

Educational Opportunities. The extensive involvement of faculty in energy research has created a wide range of opportunities for graduate studies in energy. Most of the departments in the College of Engineering and Applied Sciences, as well as several departments within the College of Arts and Science and the College of Business and Eonomics, are active in energy research and offer both masters and doctoral degree programs suitable for studies of energy-related topics.

All degrees are granted by the academic departments and graduate students interested in energy enroll in traditional graduate degree programs in departments of their choice. These students specialize in energy by complementing their programs with a selection of special energy-related courses. They pursue their graduate research in energy areas under the supervision of faculty from the Energy Research Center or from other research centers or academic departments.

Opportunities also exist for students to receive part of their training in industry through a program in which a graduate student involved in energy can do a research internship in industry under the joint supervision of company research staff and the student's faculty adviser. The Energy Intern Program is individualized: each internship is designed to meet the specific needs and interests of the student, the faculty adviser and the company.

Financial support for graduate students is available through the Energy Research Center by means of fellowships and research assistantships related to sponsored research.

Each year Lehigh faculty members offer a number of special energy-related courses at the undergraduate and graduate levels; many of them are outgrowths of current faculty research. Recent examples include courses dealing with energy economics, the international politics of oil, nuclear reactor engineering, public policy and nuclear power, air pollution, coal catalysis, coal technology, materials for modern energy systems and solar energy.

The Energy Research Center also sponsors an annual seminar series, bringing some of the outstanding people in the energy fields to the campus to speak. Covering a range of topics from economics to energy policy to science and engineering, these seminars provide an opportunity for faculty and students to learn of new developments in energy.

For more information, write to Edward K. Levy, director, Energy Research Center, Lehigh University, Bethlehem, Pa. 18015.

Engineering Research Center For Advanced Technology For Large Structural Systems (ATLSS)

The ATLSS Engineering Research Center was established in May 1986 with a grant from the National Science Foundation (NSF) to assist structures-related industries. Currently, about 35 persons, including graduate students, research associates, faculty and staff members representing the various disciplines important to large structural systems are active in research at the Center.

The Center has three main research thrusts: Advances in Design Concepts, Innovation in Fabrication and Construction, and In-Service Monitoring and Protection. Each thrust addresses the critical needs of a different section of the structures industry. The Center is cross-disciplinary, drawing from disciplines such as design, materials, manufacturing, robotics, computer-technology, chemistry and coatings technology. Faculty and students with expertise in the business, marketing, economics, and finance disciplines also evaluate the Center's research projects in terms of eventual payoff to structures-related industries. Most of the ATLSS research studies are conducted in close association with advisory committees of engineers and scientists from industry, government, design and professional groups and other universities.

In addition to the excellent research facilities and equipment already available at Lehigh, including the structural testing facilities of the Fritz Engineering Laboratory, the ATLSS Research Center will utilize major new facilities commencing in late 1987. These new facilities will include a world-class large-scale multidirectional loading facility with which researchers will evaluate large complex connections, assemblages and structures under static and/or cyclic loading. Computer-controlled testing at the new facility will include distributed control of tests; data acquisition, processing and display, and report production.

Research Activities:

Advances in Connection Technology—an integrated effort to advance connection technology in steel, concrete and mixed construction and to establish a connection design methodology through cross-disciplinary research involving steel designers, concrete designers, fabricators, computer scientists, material scientists and metallurgists.

Knowledge Base for Steel Structures—an interim step for developing a national Technical Information Center for Steel Structures that will make available technical information from both published and unpublished reports so as to respond to requests for data directly related to specifications and design criteria.

Development of Construction Robotics Technology—the application of robotics to the construction environment for a variety of tasks, such as heavy lifting, painting, stone cutting, water-jet cutting, sawing, bolting, riveting and inspection.

Knowledge-based System for the Designer-Fabricator Interface—the development of a real-time decision support system that will enable designers and fabricators to collaborate efficiently in evaluating design alternatives and making appropriate fabrication decisions for construction projects.

Knowledge-based System for Fatigue and Fracture Evaluation of Steel Bridges—the development of a portable knowledge-based expert system to guide an engineer through a bridge inspection, to shorten the inspection time and enhance the quality of the inspection.

Diagnostic Corrosion Sensors—the development of a minute pH sensors that can be placed within or in close proximity to a structural crevice. The pH can then be monitored to detect metal corrosion and structural deterioration when moisture invades the crevice.

Educational Opportunities:

The ATLSS Center facilitates programs of study and research that cross the traditional boundaries of science and engineering curricula, providing a fundamental, broad approach to the field of structures.

Graduate students participating in the Center's program usually receive master of science or doctor of philosophy degrees in the academic discipline of their choice, i.e., civil engineering, material science and engineering, computer science, industrial engineering, mechanical engineering, etc. However, they are expected to pursue course work related to a broader understanding of structures and to conduct research on a cross-disciplinary problem in the Center.

Financial support for graduate students is available through the ATLSS Research Center by means of fellowships and research assistantships related to sponsored research programs.

Undergraduates are also encouraged to participate in the Center's research and educational program. Opportunities for summer internships are available which will enable more intense and direct involvement in the Center's research effort.

For more information, write to the Director, John W. Fisher, Fritz Engineering Laboratory 13, Lehigh University, Bethlehem, PA 18015.

Environmental Studies Center

The Environmental Studies Center is a multidisciplinary research organization with the primary purpose of fostering research opportunities in the broad fields of environmental science and engineering, coastal engineering, estuarine ecology, aquatic chemistry and biology, and environmental studies.

The center staff includes faculty and graduate students from the departments of biology, chemistry, civil engineering, geological sciences, mechanical engineering and mechanics, physics, chemical engineering, economics, social relations and urban studies.

Effective utilization of the resources of the environment and their protection requires the cooperation of many scientific and engineering disciplines. Practical solutions will most likely be achieved for the many critical environmental problems facing the world through a combination of engineering and scientific talent, coupled with economic and political decision making. An environmental scientist or engineer needs an unusually broad background in many disciplines, as environmental problems are invariably cross-disciplinary in nature, i.e., solid, hazardous wastes.

Research activities. A broad spectrum of research activities is included within the scope of the center. Although much of the research is done in facilities of various academic departments, CMES has laboratories in Williams Hall (environmental biology and marine sedimentology), in Chandler-Ullmann Hall (environmental engineering, estuarine ecology, environmental geotechnology), Fritz Laboratory (water and waste-water analysis and treatment), and an off-campus estuarine and marsh station near Stone Harbor, N.J. Lehigh University is a member of the New Jersey Marine Sciences Consortium and has access to its facilities, laboratories, and boats.

Current research activities reflect the interests of the present center staff, and include: physiologic response of marine invertebrates to sublethal pollutants; reproductive strategies of shipworms in coastal thermal effluents; coastal salt marsh food-chain relationships; marine vertebrate behavior studies; biochemistry of marine bacteria; nearshore sedimentation; oceanic sedimentation on the continental slope and rise; beach sedimentation processes; control, management and treatment of toxic and hazardous wastes; waste soil interactions; effects of industrial and municipal pollution on surface and subsurface water resources; advanced wastewater treatment methods; improved control of treatment plants through automation; acid deposition effects; economics of resource development and environmental protection; and utility planning and management.

Educational opportunities. Graduate students may undertake thesis or dissertation research under the supervision of faculty associated with the center, who are members of an academic department; all courses are taught within academic departments. The program of courses to meet the student's special field of interest and to satisfy departmental and Graduate School requirements is determined by consultation with the academic department chairperson or a special departmental faculty committee.

Environmental engineering and coastal engineering courses are offered by the civil engineering department. Courses related to environmental studies and marine science are offered by the departments of biology, chemistry, chemical engineering, civil engineering, geological sciences, economics, and government.

For more information, write to the chairperson of the appropriate academic department, or to the center director, Irwin J. Kugelman, Chandler-Ullmann Hall 17, Lehigh University, Bethlehem, Pa. 18015.

Fairchild-Martindale Center for the Study of Private Enterprise

The Fairchild-Martindale Center for the Study of Private Enterprise was established in 1980 by a gift from Harry and Elizabeth Martindale. The primary purpose of the center is to contribute through scholarship to the advancement of public understanding of the structure and performance of our economic system.

Attention is focused on the private sector of the economy and on public policies as they influence the private sector. To achieve this end, the center activities include the sponsorship of lectures and conferences, support of faculty research, administration of the visiting scholar and executive in-residence programs, publication of center research, publication of the journal PERSPECTIVES ON BUSINESS AND ECONOMICS, and a center associates program for a select group of undergraduate students in business and economics.

For more information, write to the center's director, J. Richard Aronson, Fairchild-Martindale Center for the Study of Private Enterprise, Drown Hall 35, Lehigh University, Bethlehem, Pa. 18015.

Fritz Engineering Laboratory

Founded in 1909, Fritz Engineering Laboratory is involved in the advancement of knowledge and techniques in the fields of structures, structural mechanics, materials, hydraulics and fluid mechanics and geotechnics.

The laboratory is associated primarily with the department of civil engineering. In addition, there are cooperative research efforts with other departments and with other institutes and universities. Research projects are sponsored by national research councils, through the university office of research, and by industry and governmental agencies.

Graduate studies combined with research investigations commenced at Fritz Engineering Laboratory in 1928. A major expansion of the facilities in 1955 was followed by addition of equipment to meet the needs of new research opportunities.

The staff consists of faculty members, research associates, research assistants, and supporting technical personnel. The

laboratory awards research assistantships and certain fellowships to competent research personnel who are candidates for advanced degrees. Students from departments and divisions such as civil engineering, metallurgy, mechanical engineering and mechanics, and information science are able to take advantage of research opportunities with the laboratory.

Through their work in research programs, individuals are trained for careers in teaching, in research, and in advanced engineering design.

Research activities. The current research divisions indicate present interests and activities of the laboratory staff and include the following:

Fatigue and fracture (brittle failure due to cyclic and impact loading); geotechnical engineering (soil, foundation, rock and pavement mechanics); hydraulics (stream and channel flow, hydrology, sediment transport in pipes and channels, coastal engineering, groundwater movement); building systems (behavior and strength of building components, frames and over-all systems, problems involved in the design of high-rise buildings, earthquake and wind responses); structural concrete (prestressed and reinforced concrete bridges and buildings); structural connections (welded and bolted joints, composite structures); and structural stability (buckling of plates, beams, columns and frames); environmental engineering (hazardous waste control, water supply, solid-waste incineration).

The operations division provides services for laboratory work, and includes an instrumentation group and a computer systems group, the latter maintaining close liaison with the university's computing center.

As a result of the research studies conducted by the staff of the laboratory, it has been possible to make basic changes to design procedures and specifications in many specialty fields. The laboratory participates in a worldwide exchange of research information, maintains a library of technical papers appropriate to its fields, and stimulates the publication of papers in technical journals both in this country and abroad.

Educational opportunities. Through the laboratory organization, technical seminars and lectures are presented on current research findings and on new design applications in the various fields of civil engineering and related disciplines.

Courses students select are primarily in their own department. However, to gain a broader understanding, many students choose courses from the departments of biology, chemical engineering, chemistry, civil engineering, geological sciences, industrial engineering, mechanical engineering and mechanics, and metallurgy and materials engineering.

For more information, write to Irwin J. Kugelman, Fritz Engineering Laboratory 13, Lehigh University, Bethlehem, Pa. 18015.

Institute for Metal Forming

The Institute for Metal Forming, sponsored by the department of materials science and engineering, was established in 1970 to teach the principles and applications of metal-forming technology to graduate and undergraduate students; to provide instruction and equipment for graduate research in metal-forming processes; and to assist industry with solutions to problems in metal forming.

Metal-working processes are analyzed mathematically, usually involving the computer. The results of the analyses are checked and refined by comparison with experimental data obtained in the fully instrumented metal-forming laboratories that are part of the institute's facilities.

In addition, an important part of the effort of the institute is the preparation of educational programs using the latest audio-visual techniques in integrating expert systems provided as software for personal-computer users. These programs are used in the classroom and in institute-sponsored seminars on campus and at industrial facilities.

Long-range planning, together with major equipment acquisitions and construction, is supported by university funds, federal funds, and an industrial consortium.

Research activities. Current research areas include: hydrostatic estrusion; pressure-induced ductility; flow through converging conical dies; effect of holes, inclusions and pressure on tensile properties; friction modeling and measurement; cladding and forming of composite materials; forming of polymers; deep drawing, impact extrusion and iron rolling; and powder consolidation.

Educational opportunities. Students interested in metal forming should refer to course descriptions in Section V for metallurgy and materials engineering and mechanics. In addition, the institute offers special informal seminars and lectures for graduate students.

For more information, write to the director, Betzalel Avitzur, Whitaker Laboratory 5, Lehigh University, Bethlehem, Pa. 18015.

Institute for Robotics

The Institute for Robotics was established in August, 1982, to foster interdisciplinary education and research related to industrial robotics, to draw on the various disciplines for which pertinent robotics-related problems exist, and to encourage and support the development of undergraduate and graduate courses in industrial robotics. The creation of the Institute for Robotics is a formalization of the ongoing activity in industrial robotics at Lehigh since the late 1970s. More than twenty-three faculty members from five departments in the College of Engineering and the College of Arts and Science are performing research in robotics or in robotics-related areas.

The institute serves a dual function of fostering educational programs and providing research facilities and opportunities at both the undergraduate and graduate levels. As a first step, the institute has established a robotics laboratory to be used as a teaching vehicle in support of courses. The laboratory is equipped with several teaching robots with micro-processor and computer control systems for experiments in industrial robotics. In addition to the teaching robot laboratory, the institute is establishing a major research facility with industrial-grade equipment. Equipment and software have been installed and are being gathered to set up manufacturing cells. This facility will also provide robotics research capabilities in areas including welding, assembly, flexible manufacturing systems, and the interface of robots with machine tools and material handling systems. A significant portion of the needed equipment has been gathered to date with the help of industrial and governmental grant and research projects.

Research interests. Members of the institute have research interests in a variety of areas including the following: robot programming languages, operating systems and simulation; the design and analysis of robot manipulators under static and dynamic conditions; distributed control architecture for robots and factory systems; control of sensors and the integration of sensors to robots systems; pattern recognition image processing and voice processing; the link between robots and CAD/CAM systems to use common data bases as well and to develop computer assisted robot programming using graphic techniques; simulation of robots and manufacturing cells; the interface between robots and other components of the factory floor, and the connection to factory control systems; and the design of special purpose and articulated hands for robot applications.

New courses have been developed and several undergraduate senior projects, master theses, and Ph.D. dissertations are underway. Students interested in the Institute for Robotics are encouraged to contact the institute directly for an up-to-date profile of institute courses, research opportunities, and activities.

For more information, write to Roger N. Nagel, director, Institute for Robotics, H.S. Mohler Laboratory 200, Bethlehem, Pa. 18015.

Institute for the Study of the High-Rise Habitat

The Institute for the Study of the High-Rise Habitat was established in January, 1983, by the trustees of Lehigh

University for research and instructional programs. It provides a focus for studies of both the technological and socioeconomic aspects of tall buildings, as well as their role in the urban habitat. The dissemination of new findings and the development of information data bases are key elements in the program.

Established at Lehigh, and associated with the institute is the headquarters of the Council on Tall Buildings and Urban Habitat. The Fazlur Rahman Khan Chair, an endowed faculty position for research, instruction, and lecturing, is established within the context of the institute.

The Institute for the Study of the High-Rise Habitat demonstrates its concern not only with the high-rise buildings, but also with the entire scope of the urban environment. There is concern about the liveability of the structure, its suitability to the environment for which it is planned, and the urban planning and design problems that exist as a whole.

The institute, situated on the campus of Lehigh University and backed by the university's history of involvement with the study of tall buildings, provides a center for study, research activities, information dissemination, and stimulation of the use of new information in design.

A forum for faculty discussion. The institute provides a forum for faculty discussion, not only from the different disciplines on the campus as they relate to the high-rise habitat (architecture, history, business and economics, informational science), but also for visiting fellows and professors.

Research. The institute provides the opportunity to identify research problems and seek mechanisms for their solution, either in the traditional mode or in a workshop environment. This can include the traditional single-discipline research, inderdepartmental projects and joint projects carried out with other universities.

Special lectures and short courses. The institute hosts special lectures and seminars for students and visitors on selected topics, to be given by faculty and other specialists in the field. The institute organizes short courses on campus or elsewhere. Special study programs can be arranged that include a lecture series at Lehigh followed by visits to selected cities for on-the-spot evaluation. These can be arranged for multi-professional teams of visiting specialists.

Study opportunities. In addition to special study programs for graduate and undergraduate students, the resources of the institute are available to visiting scholars.

For more information write to Lynn S. Beedle, director, Institute for the Study of the High-Rise Habitat 13, Lehigh University, Bethlehem, Pa. 18015.

Institute of Fracture and Solid Mechanics

The Institute of Fracture and Solid Mechanics was established in the fall of 1970 to enable faculty members and students within the university to participate in research relevant to fracture and solid mechanics on an interdisciplinary basis.

An area of special interest to the institute has been in fracture mechanics, which deals with the study of structural and material sensitivity to flaws. Such flaws can seriously affect the design and strength of ships, aircraft, automobiles, bridges and buildings. In the design of nuclear power plants, the incorporation of the fracture mechanics concept of safety in the presence of flaws is required. In addition, fracture mechanics is finding application in such areas as bone fracture, envrionmentally accelerated cracking of pavements and structural members, the fracture of rocks, and erosion of materials by solid or water particle impingement.

The institute centralizes many activities in the field of solid and fracture mechanics. These activities include: expansion of research capabilities to include the application of concepts of fracture mechanics to geology (rocks), medicine (bones), and composite materials; editing books on timely subjects in fracture and solid mechanics; compilation and collection of written materials to establish and maintain a special library of fracture mechanics; planning of conferences on fracture and solid mechanics; offering short courses and seminars on special topics; conducting liaison programs with industry and government agencies.

Research activities There are several research programs being conducted in solid and fracture mechanics, sponsored by industry and governmental agencies. They include:

Fracture mechanics. Analytical: stress analysis of engineering structures weakened by flaws; spherical and cylindrical shells with mechanical imperfections; crack extension in viscoelastic and rate sensitive materials; thermoelastic analysis of crack problems; heat generation at the crack tip region in metals; vibration and impact of solids containing cracks; three-dimensional analytical and finite element studies of surface and through cracks; fracture behavior of layered and fiber-reinforced composites; elastic-plastic solutions of crack problems.

Experimental: static and dynamic fracture roughness testing of metallic, nonmetallic and composite materials; crack-extension resistance curve measurements for aluminum and titanium alloys and steels; glass-to-rubbery transition temperature in viscoelastic materials; velocity measurements of running cracks; fatigue crack propagation in pressurized shells and shells under membrane load; combined loading (biaxial, tension-bending, etc.) of thin plates with cracks; photoelastic studies of stress distribution in cracked and composite bodies; environmental effects on crack propagation under static cyclic loads; fatigue crack propagation under programmed loading; gaseous hydrogen embrittlement.

Solid mechanics. Analytical and numerical methods of analysis: conformal mapping technique applied to potential solutions; two-and three-dimensional asymptotic expansions near geometric discontinuities; integral transform solutions leading to Fredholm integral equations; singular integral equations with generalized Cauchy kernels; application of the Chebyshev and Jacobi polynomials; methods based on the Gauss-Jacobi quadrature formulas; special applications of numerical treatment and finite elements to continuum problems involving singularities; convergence of finite element solutions for continuum mechanics problems.

Plates and shells; development of advanced plate and shell theories; load-deflection and instability behavior of elastic and plastic shells of revolutions; composite and sandwich shells subjected to static and dynamic loadings; dynamics of magnetoelastic shells.

Educational Opportunities. Students interested in fracture and solid mechanics should refer to course offerings in the departments of mechanical engineering and mechanics, metallurgy and materials engineering, civil engineering, chemistry and biology.

For information, write to the director, George C.M. Sih, Packard Laboratory 19, Lehigh University, Bethlehem, Pa. 18015.

Institute of Thermo-Fluid Engineering and Science

The Institute of Thermo-Fluid Engineering and Science, established in 1978, provides a focus for research and educational activities in fluid mechanics, thermodynamics, and heat transfer.

This institute seeks to consolidate the substantial ongoing research effort in these fields, to aid in the further development of such research, and to facilitate the utilization of this interdisciplinary strength in the university's educational programs.

Currently twenty-five full-time faculty and staff from the departments of chemical engineering, mechanical engineering and mechanics, mathematics, and physics are among the institute members. Graduate students and undergraduates as well as part-time and visiting staff members, join in the institute's activities.

Research facilities for thermo-fluids programs are based in the College of Engineering and Physical Sciences. Among the facilities available are laboratories for experimental investigations of fluid mechanics, gas dynamics, turbulent structure, solid-gas fluidization, boiling heat transfer and two-phase flow, refrigeration and heat pump systems, internal combustion engines, radiation and optical measurements, unit

operations, and control dynamics. The university's Computing Center as well as various minicomputers are available for use in analytical computations.

The institute also conducts the Thermo-Fluids. Liaison Program, to promote the interchange of knowledge between the researchers at Lehigh and the engineers and scientists in industry and government. In cooperation with companies participating in the liaison program, the institute's staff members seek to apply their specialized capabilities in thermo-fluids to current industrial and governmental engineering and scientific problems.

Research activities. The institute's staff members are involved in three interrelated areas: fluid mechanics, heat transfer and thermal science, and applied thermodynamics and modeling.

Combining experimental investigations with theoretical analyses, the researchers seek to understand and quantify the phenomenological mechanisms governing thermo-fluid processes. This knowledge is then brought to bear on relevant engineering problems of current concern in such applications as energy conservation, power production, coal conversion, aerodynamics, weather modeling, and nuclear energy.

The institute's current research program includes more than eighteen grants sponsored by industry and various governmental organizations. A wide spectrum of subjects are under investigation, including research on flow-induced vibrations, unsteady turbulent flows, solar and wind energy measurements, coherent turbulent boundary layer structures, blade flutter in compressors and fans, stochastic optimal control, application of finite elements for weather modeling, colloid size distributions by hydrodynamic chromatography, centrifugal fluidized combustion of coal, heat transfer in fluidized beds, heat pump systems, two-phase flow instrumentation, boiling heat transfer and two-phase flows, and nuclear reactor thermal safety.

Educational opportunities. Formal courses in fluid mechanics, heat transfer, and thermodynamics are offered in the College of Engineering and Physical Sciences. Institute staff members regularly teach both undergraduate and graduate courses in the departments of mechanical engineering and mechanics, chemical engineering, and physics. Undergraduates can select a program of study, in consultation with their adviser, with emphasis on thermo-fluid sciences by elective choices among the departmental offerings. A formal minor program in fluid mechanics is available. Graduate studies leading to the M.S. or Ph.D. with concentration in thermo-fluids are available in the three departments.

Participation by both undergraduate and graduate students in the thermo-fluids research activities is encouraged. Many undergraduates participate as individuals or as groups in term projects under the supervision of institute faculty members. This provides an opportunity for interested students to obtain first-hand experience in pioneering thermo-fluids research. The research programs directed by institute staff members also provide support for graduate research assistantships, enabling selected graduate students to pursue their education and research in thermo-fluids on either a part-time or full-time basis.

In cooperation with various academic departments, the institute sponsors seminars by both staff specialists and by invited speakers from other institutions. These seminars are open to the university community, liaison program participants, and to engineers and scientists from neighboring industries. The institute anticipates organizing topical meetings, workshops, and short courses on specialized subtopics within the over-all discipline. Meeting topics will be selected to reflect ongoing research activities of the staff members and contemporary engineering concerns.

For information regarding the Institute of Thermo-Fluid Engineering and Science, write to the director, John C. Chen, Whitaker Laboratory 5, Lehigh University, Bethlehem, Pa. 18015.

Lawrence Henry Gipson Institute for Eighteenth-Century Studies

The Lawrence Henry Gipson Institute for Eighteenth-Century Studies, established in 1971, serves as a memorial to one of America's most distinguished scholars, and long-time member of the faculty at Lehigh.

It helps to support the research activities of the Lehigh community of humanists and social scientists interested in developing a further understanding of the period of history epitomized in Professor Gipson's monumental life work, *The British Empire Before the American Revolution* (15 volumes, written from 1936 to 1970). The professor won the Pulitzer Prize for Volume 10.

Through its council, the Gipson Institute awards research grants and fellowships from the income of its endowment, a fund made possible by Professor Gipson's bequest of his entire estate to Lehigh. To further the scope of the original endowment, the council of the institute seeks additional support by promoting research and other programs related to the eighteenth century.

Research activities. The income from the endowment of the Gipson Institute, and other funds, provide faculty research grants to defray travel cost, microfilming, and other such expenses; graduate student grants to help support deserving students during their dissertation year; internal seminars to bring together the eithteenth-century interests of faculty and graduate students and to stimulate interdisciplinary research activities. These seminars are broad in scope and include faculty from neighboring institutions. Interdisciplinary graduate courses in eighteenth-century studies provide students, who normally concentrate on one discipline, with a grasp of other significant developments and an understanding of the rich cultural and intellectual milieu of the eighteenth century. Such courses stress the interrelationship of history, politics, literature, fine arts, philosophy, psychology, and the sciences.

Annual symposia honor Professor Gipson, involving distinguished scholars in eighteenth-century studies to lecture and also discuss opportunities for further scholarly exploration. The institute also provides additional research resources for the library, as well as faculty and student fellowships for the pursuit of research in an eighteenth-century topic.

Educational opportunities. Among the academic departments involved in eighteenth-century studies are English, government, history, modern foreign languages and literature, art and architecture, music, philosophy, psychology, and social relations.

For more information, write to the coordinators, James S. Saeger, department of history, or Jan Fergus, department of English, Maginnes Hall 9, Lehigh University, Bethlehem, Pa. 18015.

Lehigh Valley Center for Jewish Studies

The Lehigh Valley Center for Jewish Studies, established in 1984, develops, administers, and coordinates programs in Jewish studies among member institutions of the Lehigh Valley Association of Independent Colleges (LVAIC) (Lehigh University, Muhlenberg College, Lafayette College, Moravian College, Cedar Crest College, and Allentown College of St. Francis de Sales). Building upon existing resources, the center supports and encourages shared course offerings as well as the exchange of faculty among LVAIC institutions. Beginning this year, three additional faculty in Jewish Studies, housed at Lafayette College, Lehigh and Muhlenberg College, will be associated with the center. In addition to teaching on their home campuses, these faculty will offer Jewish studies courses on other LVAIC campuses each semester. A visiting scholar, most likely from Israel, will also be teaching at one or more LVAIC schools each year. Housed at Lehigh, the Center for Jewish Studies is directed by Laurence J. Silberstein, Philip and Muriel Berman professor of Jewish Studies.

Activities of the center include designing and implementing new courses and seminars, establishing research grants for undergraduate students, sponsoring study programs abroad for undergratuates, organizing annual lecture series, and sponsoring colloquia and conferences in Jewish studies at LVAIC institutions. The center coordinates year-long,

semester and summer study programs in Israel at the Hebrew University, Tel Aviv University, and the Tel Miqne-Ekron Archaeological Project. For further information on Israel study programs, contact Dr. Myra Rosenhaus, 758-3352.

Philip and Muriel Berman of Allentown, Pa., in consultation with Judaic scholars from the United States and Israel, conceived of and provided the initial funding for the center. Their goal was to establish in the Lehigh Valley a first-class academic program for the study of all aspects of Jewish civilization. The center customarily opens its programs to the public.

For more information about the Center for Jewish Studies, please contact Dr. Laurence J. Silberstein, 758-4869.

Materials Research Center

The Materials Research Center was established in 1962. Currently, approximately 140 persons, including graduate students, research associates, and faculty members representing science and engineering departments, are engaged in research pertaining to materials science and engineering.

The fundamental objectives of the Materials Research Center are to encourage interaction among the science and engineering disciplines with an interest in materials and to promote interdisciplinary research activity and interdepartmental educational opportunities. To achieve these objectives, the center seeks to establish a climate in which faculty members, research scientists, postdoctoral associates, and graduate assistants develop an awareness of materials, arrange for facilities and space required to conduct interdisciplinary research; guide the search for new materials by encouraging fundamental research and new approaches to materials problems; and assist in developing educational opportunities in materials—in particular, interdisciplinary graduate programs devoted to training for research in materials.

The center also conducts the Materials Liaison Program. Founded in 1963, this program promotes the interchange of knowledge between the materials community at Lehigh and engineers and scientists in industry and government. The program conducts seminars on materials research, special lectures and workshops on items of current interest; consults on materials problems and research; distributes master of science and doctor of philosophy theses and abstracts of materials research; and sponsors seminars with outstanding invited speakers.

The staff consists of members of the departments of chemistry, chemical engineering, computer science and electrical engineering, mechanical engineering and mechanics, materials science and engineering, and physics. Members of other departments and centers frequently are involved in cooperative programs. Communication with these associated units is achieved through the Materials Research Council, which is composed of senior faculty members from all of the engineering departments as well as from the department of geological sciences and appropriate research centers. The council serves in an advisory capacity as well.

Research Activities. The present organization of the Materials Research Center includes five laboratories: the electronic materials laboratory, located in the Sherman Fairchild Laboratory; the electron optical and ceramics research laboratories, located in Whitaker Laboratory; and the mechanical behavior and polymer laboratories, located in Coxe Laboratory. Current interdisciplinary research activities include:

Electronic materials. Preparation and properties of materials for solid-state devices; characterization of metal oxide films using optical and electrical methods emphasizing metal-insulator-semiconductor structures; defect structure and impurity interactions in amorphous and crystalline materials in both bulk and thin-film form; interfacial segregation and phase formation in metal-oxide systems.

Electron optics. Characterization of fracture surfaces in polymers and steels by scanning electron microscopy; x-ray microanalysis of extraterrestrial materials, ferrous alloys, geological materials and ceramics using the electron probe microanalyzer; transmission and scanning transmission electron microscopy studies of grain boundaries in oxides; discontinuous precipitation in non-ferrous alloys; low-temperature phase transformations in iron materials; inclusions in weld structures of ferrous alloys; and glass metal reactions in lunar samples.

Ceramics. Microstructure and solid state chemistry of electronic and electro optic oxides including both polycrystalline and single crystalline materials; degradation mechanisms in ceramic devices; deformation mechanisms, including creep and hotpressing; sintering studies and additive effects; microstructural characterization of ceramic materials.

Mechanical behavior. Effect of polymer chemistry and molecular structure on fatigue crack propagation (FCP); test frequency sensitivity and fatigue fracture micromechanisms in polymer solids; fracture characteristics of bridge steels; fatigue of weldments; corrosion fatigue crack propagation; metallurgical aspects of FCP in ferrous and non-ferrous alloys; fracture mechanism studies by transmission and scanning electron microscopy.

Polymers. Fatigue crack growth and relaxation processes in engineering plastics and composites; structure, morphology and mechanical behavior of interpenetrating polymer networks; thermosetting resins; vinyl polymers; polymers based on renewable resources; permeability and mechanical behavior of membranes, coatings, and filled polymers; novel polymer concrete systems.

Educational opportunities. This center facilitates programs of study and research that cross the traditional boundaries of science and engineering curricula, providing a fundamental, broad approach to the field of materials science and technology.

Graduate students participating in the center's program usually receive master of science or doctor of philosophy degrees in the academic discipline of their choice, i.e., chemistry, physics, materials science and engineering, computer science and electrical engineering, etc.; or in an interdisciplinary program such as polymer science and engineering. However, they are expected to pursue coursework related to a broader understanding of materials and to conduct research on an interdisciplinary materials problem in one of the center's five laboratories.

Financial support for graduate students is available through the Materials Research Center by means of research assistantships related to sponsored research programs.

For more information, write to the director, Donald M. Smyth, Coxe Laboratory 32, Lehigh University, Bethlehem, Pa. 18015.

Rauch Center for Executive Development

The Rauch Center for Executive Development was established in 1981 to help present and future managers develop communication and other interpersonal skills. The center was established with a gift from Philip Rauch, a 1933 Lehigh graduate who is retired chairman of the executive committee of Parker Hannifin Corporation.

The center's top priority is to help students improve their competence in written and oral presentation, as it affects the operation and management of a business organization. Elective courses, offered for both undergraduate and graduate students, stress the application of writing and speaking skills in typical management situations.

The Rauch Center also offers workshops for students, professional staff, and business groups. For the business community, offerings include workshops on achieving results through written communications, effective organizational leadership, and individual career development.

For the university community, the center offers communication assistance for participants in the Lehigh University Management Assistance Counseling (LUMAC), consultation help for the Fairchild-Martindale Center Student Associates, and workshops for graduate students on "How to Write Effective Theses and Dissertations."

The center also sponsors campus visits by outstanding management scholars, management communications

professionals, and business practitioners interested in the discussion of effective management techniques.

For more information, write to the director, Richard W. Barsness, Drown Hall 35, Lehigh University, Bethlehem, Pa. 18015.

Sherman Fairchild Center for Solid-State Studies

Although work in other aspects of solid-state is carried out in many locations on the Lehigh campus, the Sherman Fairchild Laboratory provides the focal point for studies of electronic materials and devices. Opened in the fall of 1976, the building provides offices and laboratories for an interdisciplinary staff consisting of faculty from the departments of physics, chemistry, metallurgy/materials engineering, and electrical and computer engineering.

Research activities. A central theme involving the nature and role of defects in insulators and semiconductors runs through the research program. Areas of study include quantum theoretical predictions of electronic properties, fabrication of materials and devices for the study of material processing; the elucidation of fundamental electronic, optical and transport behavior; design, fabrication and characterization of novel electronic devices. The research has a current emphasis on silicon, silicon oxides and silicon-related technology, but also includes work on compound semiconductors and complex insulators such as niobates and titanates.

Central to the functioning of the research program is the Microelectronics Research Laboratory, which provides processing facilities for the fabrication of CMOS, CCD, MNOS, bipolar devices and integrated circuits. Available technology includes: low-pressure chemical vapor deposition (LPCVD), RF metallization, plasma chemistry, photolithography, ion implantation, high pressure oxidation, and standard oxidation and diffusion. Design of circuits and devices is aided by an Applicon Color Graphics VLSI system, and a HP-IB system permits automatic data acquisition and analysis of device characteristics.

A 3 MeV Van de Graaff accelerator provides a radiation facility that can be used to produce electrons for the generation of point defects or positive ions for the analysis of samples—Rutherford Backscattering and proton-induced X-ray emission (PIXE). Individual laboratories provide instrumentation for studies of ceramic materials fabrication, transport properties, optical excitation and luminescence, electron tunneling, electronic conduction and trapping, electron paramagnetic resonance (EPR) and optical detection of magnetic resonance (ODMR), deep level transient spectroscopy (DLTS).

Current research programs include: (1) Fundamental radiation damage processes in silicon, an experimental and theoretical program aimed at unraveling the fundamental proprties of simple lattice point defects in silicon; (2) A study of the electronic and vibronic structure of intrinsic lattice defects in compound semiconductors, an experimental study of the fundamental properties of simple crystalline point defects in the compound (II-VI, III-V) covalent semiconductors; (3) Point defects in insulating solids, experimental studies and theoretical calculations on electron/hole transport, trapping and defective properties; (4) Tunneling in MIS memories, an exploration of the dominat physical process in nonvolatile semiconductor memories, namely tunneling of carriers into and through an insulator; (5) VLSI microelectronics, a study of the characterization of small-geometry solid-state devices for VLSI, with emphasis on CMOS transistors; (6) Semiconductor charge transport devices, a study of novel device and sensor structures that evolve charge transport and storage. The characterization and modeling of MNOS nonvolatile memory structures; (7) Microstructure of electronic materials, microstructural studies of electronic devices, passive components and processing materials to elucidate fundamental mechanisms that govern device performance, to improve device performance and explore novel methods of fabrication.

Educational opportunities. Graduate students in the field of solid-state science and engineering usually enroll for the master of science or doctor of philosophy degree in the traditional discipline of their choice, such as physics, metallurgy and materials engineering, electrical engineering, etc., with specific course requirements and research participation coordinated through the appropriate department chairperson. Students are financially supported by graduate fellowships and undergraduate scholarships provided by the Sherman Fairchild Foundation and/or by university sources. In addition, teaching assistantships are available through the departments and a number of research assistant positions are supported by research grants and contract awards obtained by the laboratory staff. All of these arrangements typically permit graduate students in the solid-state studies are to undertake three courses per semester in addition to their teaching or research activities.

For more information, write to Ralph J. Jaccodine, director, Sherman Fairchild Center for Solid-State Studies, Sherman Fairchild Laboratory 161, Lehigh University, Bethlehem, Pa. 18015.

Small Business Development Center

The Small Business Development Center was established in 1977 for the benefit of students, faculty, and owners of small businesses in the Lehigh Valley. The function of the center is to bring together in one location the skills and expertise of faculty and students with the information and resources of the various levels of government in one location for easy access by the small business community.

The center involves students in a practical learning experience as counselors to business and planners of new ventures. Counseling is provided through LUMAC (Lehigh University Management Assistance Counseling), a three-credit graded course offered each semester. Approximately fifty businesses are served each year through the efforts of ninety students each semester. The center also serves more than 1,000 clients with general business counseling by a full-time staff, part-time analysts (graduate students with previous business experience), and services the Lehigh Valley chapter of SCORE (Service Corps of Retired Executives).

Specialized counseling is provided to firms interested in establishing export markets by the International Trade Development Program (ITDP). Those companies interested in obtaining government contracts can also receive detailed help through the Government Procurement Assistance Program (GPAP). Both of these programs enlist the help of undergraduate and graduate students in serving clients of the center.

The center conducts studies regarding problems faced by small business and the impact of the general economy on the problems of the formation and operation of small business. The center also studies characteristics of entrepreneurs.

For more information, write to the center's director, John W. Bonge, Small Business Development Center, 412 S. New St., Bethlehem, Pa. 18015.

The Stone Harbor Marine Laboratory

Lehigh University, in cooperation with the Wetlands Institute, Inc., operates a year-round marine facility on a 34-acre site on the edge of a coastal salt marsh near Stone Harbor, N.J. Although this field station is designated for Lehigh faculty and students, investigators and students from other colleges and universities are encouraged to use the facility.

The general objective of the laboratory is to increase the understanding of the natural processes controlling the coastal ecosystem through fundamental research. The objective is to provide factual scientific information that can serve others as a basis on which to make intelligent environmental management

decisions. Clearly, such research will be valuable in educating the general public to the need for preserving and enhancing the coastal areas.

The facilities available to investigators and students are individual and general "dry" laboratory areas for the usual analytical equipment. The "wet" lab has a flowing sea-water system with the potential to provide heated filtered and nonfiltered sea water. The small boats are housed at the dock and provide access to offshore areas. A bird observation tower provides excellent visibility to the surrounding 4,000 acres of state-controlled marshlands. The largest breeding heronry in the U.S. is within one mile of the laboratory. Dormitory facilities, with a kitchen, are available. A photographic darkroom is available.

Research activities. Behavioral ecology of shorebirds and marsh fishes; life histories and community dynamics of benthic and planktonic invertebrates; mechanisms and ecological/evolutionary consequences of asexual reproduction and regeneration among marine invertebrates and marsh grasses; comparisons between similar tropical and temperate coastal habitats; relationships between commercially important fisheries and other members of coastal trophic webs; physiology and ecology of sublethal doses of toxic substancesin estuaries; management of industrial effluent around coastal habitats; estuarine nutrient chemistry; rates and mechanisms of estuarine sedimentation; tidal hydrology; coastal shore protection engineering; anthropological studies of commercial fishermen; and studies of the relationships between natural resource exploitation and cultural history of shore areas.

Educational opportunities. Formal graduate studies are offered through the graduate programs within the various departments of the university (e.g., biology, geological sciences, civil engineering). Research internships for advanced undergraduates desiring hands-on experience are also offered. Selected undergraduate and graduate courses are offered.

For additional information write to: Murray Itzkowitz, director, Stone Harbor Marine Laboratory, Williams Hall 31, Lehigh University, Bethlehem, Pa. 18015, or Charles Wahle, associate director, Stone Harbor Marine Laboratory, Stone Harbor Blvd., Stone Harbor, N.J. 08247.

Technology Studies Resource Center

The Technology Studies Resource Center, based in the College of Arts and Science, creates and disseminates materials and programming that will lead a wide range of people to an understanding of the mutual interaction of technology, and social institutions and values. Through the center, academics from all disciplines can collaborate on research and develop educational opportunities in technology studies with academic colleagues and with non-academic sonsors.

The Technology Studies Resource Center's activities embrace the needs of academics, pre-college and college students, and industrial, political, and public audiences, who seek information about technology as a force in contemporary society. Four principal areas for activities are the development and dissemination of resouce materials, professional development programming, educational programming, and stimulation and coordination of technology studies and research projects. Specific activities include: collecting and distributing college-level course syllabi in technology studies; publishing bibliographies in specific areas of technology studies; sponsoring a regional colloquium in technology studies and publishing its best presentations in a working papers format; editing the continuing series RESEARCH IN TECHNOLOGY STUDIES; publishing the SCIENCE, TECHNOLOGY, AND SOCIETY CURRICULUM DEVELOPMENT NEWSLETTER; maintenance of a data base of personnel, curricula, and materials resources in technology studies; sponsoring conferences, workshops, seminars and institutes in technology studies; and integrating technology studies material with existing high school curricula and developing better courses in science and mathematics in cooperation with regional administrators and faculty.

For more information write to Stephen H. Cutcliffe, Maginnes Hall 9, Lehigh University, Bethlehem, Pa. 18015.

Regional Center for Advanced Technology

The North East Tier Ben Franklin Advanced Technology Center (NET/ATC), based in the Ben Franklin Building on the Murray H. Goodman Campus, was established in 1983 to help meet the goals of the Commonwealth of Pennsylvania to create and maintain jobs, improve the productivity of new and existing businesses, and diversity the state's economy by creating and attracting firms in advanced-technology fields. A program of the Pennsylvania Department of Commerce, the center is one of four advanced-technology centers in the state; the others are based at the University City Science Center, Philadelphia; Pennsylvania State University, University Park; and Carnegie-Mellon University/University of Pittsburgh.

The center works with a consortium that includes 913 businesses and industries, 78 schools and 70 foundations, government and community organizations in northeastern Pennsylvania. Goals include developing centers of excellence in four major technologies (computer-aided design and manufacturing, microelectronics, materials, and biotechnology), encouraging the development of business incubator centers, providing outreach assistance and information, and coordinating existing resources in the region. These projects include joint research and development, which leads to new products or processes for companies; the development of education and training programs that meet the needs of industry; entrepreneurial assistance programs that encourage the development of small advanced-technology business.

For the 1986-87 funding year, the NET/ATC received $7.1 million from the state Department of Commerce; and $30.1 million in matching funds from private-sector businesses and educational institutions and other sources. About $4 million of the state's grant has been allocated for the center's general programs and 82 projects at Lehigh, involving approximately 200 faculty members, research scientists, project engineers, students, technicians, and administrative staff. It has worked with a variety of large and small businesses and industries in the north east tier of Pennsylvania, and worked with the faculty, staff, and students of a variety of educational institutions.

For more information, contact Mark S. Lang, executive director, NET/ATC, 125 Goodman Drive, Lehigh University, Bethlehem, Pa. 18015-3715; (215) 758-5200.

Drown Hall, shown at the turn of the century, is the headquarters of the College of Business and Economics.

V.

Descriptions of Courses

This section includes listings of undergraduate and graduate courses offered by Lehigh University. For purposes of record, all approved courses are listed. It must be understood, however, that the offerings in any given semester are contingent upon a number of factors, including student needs as determined at the time of preregistration.

Credit Hours

The number in parentheses following each course title indicates the credit value of the course in terms of semester hours ("credit hours"). Three hours of drawing, of work in the laboratory, or of practice in the field are regarded as the equivalent of a recitation or lecture of one hour's duration.

Course Numbering

The course numbering system specifies which courses can be applied to the program of study as the student progresses toward the undergraduate or graduate degree. In general, the numbering series is as follows:

0-99. Courses primarily for freshmen or sophomores. Not available for graduate credit.

100-199. Intermediate-level undergraduate courses. Not open to freshmen except on petition. Not available for graduate credit.

200-299. Advanced undergraduate courses. Courses in the College of Business and Economics and specific departments as noted in the listings are open to freshmen and sophomores only on petition. Not available for graduate credit in the major field.

300-399. Same as 200-299, but available for graduate credit in major field.

400-499. Graduate courses, open to undergraduates only by petition.

Provisional Courses

Each instructional department is authorized to offer provisional courses, or those offered on a trial basis, as well as special opportunities courses. Such courses can become a permanent part of the university curriculum. These courses are numbered, as is appropriate, . . 95-98 . . 195-198, . . . 295-298, . . . 395-398, for a maximum of two semesters.

Students may take 95-98 series courses pass/fail under the standard procedures for pass/fail.

Apprentice Teaching and Cooperative Undergraduate Education

For details of these programs, see descriptions under "Apprentice Teaching" and "Cooperative Undergraduate Education," listed alphabetically in this section.

Prerequisites

Academic preparation required for admission to courses is indicated under "prerequisites" included at the end of each course description. Prerequisites are stated in most cases for purposes of convenience in terms of Lehigh courses. Academic status required for admission, where numbering does not fully describe this status, is also indicated under "prerequisites."

A student who does not have the status (e.g., sophomore standing) or the academic preparation set forth as prerequisites must, in order to be admitted to a course, file with the registrar at the time of registration and on a standard form provided, a waiver of prerequisites signed by the chairperson or head of the teaching department or division, and the student's curriculum director. Academic work completed elsewhere must be attested in this manner as being substantially equivalent to prerequisites listed, unless the student's records in the Office of the Registrar show that the proper officers have so evaluated this preparation previously.

Engl 2, 3, 6, 8 and 10 are prerequisites to all 100- or higher-level courses. Exceptions may be made only by petition to the Committee on Standing of Students.

In a few cases, corequisites are indicated. In such instances the corequisite course is taken in the same semester.

Abbreviations

Whenever possible, course listings contain information indicating what requirements the course satisfies, the semester or semesters in which it is offered, and the name of the scheduled instructor or instructors.

While all information herein is subject to change, the information is included to serve as a guide in the selection of appropriate courses that best fulfill the student's academic requirements and personal goals.

The symbols following course titles for some College of Arts and Science courses include:

NS. Psychology department courses that meet the Natural Science distribution requirements.

SS. Psychology department courses that meet the Social Science distribution requirements.

Chemistry and Physics

Effective July 1, 1987, the departments of chemistry and physics, traditionally associated with the College of Engineering and Physical Sciences, will join other science departments administered within the College of Arts and Science. Reflecting the change, the former will become known as the College of Engineering and Applied Science. Because the change is primarily related to the university's organization, students enrolled in chemistry and physics will not be significantly affected in their course work.

Status of Divisions

A number of areas of study are listed independently of the parent department's entry. For example, Astronomy, taught in the mathematics department, is listed under Astronomy. Similarly, courses offered by divisions of departments are listed alphabetically rather than with the departmental entry. Among such courses are speech and theater (division of the English department). A number of language courses are listed under the entry for the department of modern foreign languages, rather than alphabetically.

Faculty Identification

In many cases, the names of professors scheduled to teach a course are listed at the conclusion of the course description entry. In most instances, those identified in this way are listed as faculty members in the introductory section to each department. In a few cases, however, the teacher may be associated with another department. In any case, identification of the individual and his or her credentials may be found in the alphabetical listing of faculty members in Section VII.

Information Limits

The course descriptions are intended to guide the student in selecting appropriate courses. For reasons of space, descriptions are brief. In most cases, courses will have a significantly broader scope than the topics listed in the description. In some courses, material may change from what is described. If there is doubt concerning the appropriateness of any course for the individual's educational objectives, it is suggested that the student confer with the adviser.

A Choice of Titles

Note: Principal officers of academic departments are identified as *chairpersons* in most cases. Individuals who prefer to be known as *chairmen* are identified accordingly. The responsibilities are identical regardless of which term is used.

Accounting

Professors. James A. Largay, III, Ph.D. (Cornell), *C.P.A., Arthur Andersen & Co. Alumni Professor of Accounting;* Frank S. Luh, Ph.D. (Ohio State); Robert H. Mills, Ph.D. (Wisconsin), *C.P.A.*
Associate professors. D. Raymond Bainbridge, Ph.D. (Lehigh), *C.P.A.;* James A. Hall, Ph.D. (Oklahoma State); John W. Paul, Ph.D. (Lehigh), *C.P.A.;* Kenneth P. Sinclair, Ph.D. (Massachusetts); Stuart K. Webster, Ph.D. (Iowa), *C.P.A., chairman.*
Assistant professors. John Kercsmar, Ph.D. (Houston), *C.P.A.;* Michael L. Davis, Ph.D. (Massachusetts), *C.P.A.*
Instructors. Brian Carpenter, M.B.A. (Scranton); Parveen P. Gupta, M.B.A. (Connecticut); Robyn Lawrence, M.S. (California State).

The Department of Accounting offers a wide variety of courses in accounting which: support the College of Business and Economics core requirements; provide an undergraduate major in accounting; are elective courses for other College of Business and Economics undergraduate majors; and form a key component of the Master of Business Administration program. The upper-level undergraduate courses have a professional accounting orientation which continues to sustain a large enrollment in the accounting major. Within the major, there is the opportunity to explore the various career opportunities within the broad field of accounting: financial, managerial, taxation, auditing, and information systems.

Objectives of the Accounting Program

The primary goals of Lehigh's undergraduate program leading to the Bachelor of Science degree in Business and Economics with a major in accounting are to:

Cultivate an inquiring mind and kindle the student's interest in lifelong learning

Subject the student to a rigorous academic program in the liberal arts in addition to business and economics

Provide the student with a theoretical framework as well as problem-solving skills in each of the following areas in accounting: financial, managerial, information systems, auditing, and taxation

Encourage the development of interpersonal skills including oral and written communication skills

Promote self-development through participation in extracurricular and social activities.

To the extent the above objectives are achieved, the graduate is prepared for the following: an entry level position in industry, not-for-profit organizations, public accounting; self-employment; and graduate studies. This academic program prepares interested students for relevant professional accounting examinations.

The Accounting Major

The undergraduate program in accounting is accredited (Type A) by the American Assembly of Collegiate Schools of Business. This achievement places the program within a small group of schools nationally which have satisfied a rigorous examination of the program, faculty, and students beyond the accreditation standards applied to the College of Business and Economics undergraduate and graduate programs.
The program is offered in the College of Business and Economics. Required: 18 credit hours beyond core requirements.

Acct 307	Fundamentals of Federal Income Taxation (3)
Acct 311	Accounting Information Systems (3)
Acct 315	Financial Accounting I (3)
Acct 316	Financial Accounting II (3)
Acct 320	Fundamentals of Auditing (3)
Acct 324	Cost Accounting (3)

Undergraduate Courses in Accounting

51. Introduction to Financial Accounting (3)
The organization, measurement and interpretation of economic information. Introduction to accounting theory, concepts and principles, the accounting cycle, information processing, and financial statements. Exposure to controversial issues concerning income determination and valuation. Prerequisite: sophomore standing.

52. Introduction to Managerial Accounting (3)
An introduction to internal accounting information for all levels of management. Topics include cost flow in a manufacturing operation; planning, evaluating and controlling through budgeting and standard costing; and decision-making using cost-volume-profit analysis, direct costing, and relevant costs. Prerequisite: Acct. 51.

108. Fundamentals of Accounting (3)
A one-semester survey of accounting principles and practices, including an introduction to industrial cost systems designed for those students planning to take only one accounting course. Other students should take the Acct 51-52 sequence.

111. Management Information Systems in Business (3)
An introduction to information systems with an emphasis on business applications. Students develop a working knowledge of a computer language sufficient to solve business problems. Basic knowledge of hardware, software, computer systems, and the systems development process. File organizations, the data base concept and distributed data processing systems are covered.

Advanced Undergraduates and Graduate Students

307. Fundamentals of Federal Income Taxation (3)
An introductory study of the principles and concepts of federal income taxation of individuals, corporations, partnerships, and fiduciaries; and federal gift and estate taxes. Determination of tax liabilities and opportunities for planning are emphasized. Problem-solving using the source materials of tax law and tax research are important components of the course. Prerequisite: Acct. 51.

309. Advanced Federal Income Taxation (3)
An advanced study of the taxation of business organizations, estates, trust, and wealth transfer taxes. Planning and research are the basic components of the course. Problem-solving and written research are emphasized. Prerequisite: Acct. 307

311. Accounting Information Systems (3)
An introduction to the concepts underlying information systems as they relate to organizational structure, managerial decision making and accounting. The course acquaints students with the reports and documents generated by information systems, as well as procedures and controls employed in a variety of business applications. Students apply these concepts, techniques and procedures to the planning, analysis and design of manual and computer based information systems. Prerequisites: Acct. 52 and 111.

315. Financial Accounting I (3)
Intensive study of the basic concepts and principles of financial accounting, emphasizing the problems of fair presentation of an entity's financial position and operating results. Consideration of the conceptual framework of accounting, review of the accounting process, and measurement and valuation of current assets, current liabilities, plant assets, intangibles, investments, and long-term debt. Problem-solving skills and critical analysis are stressed. Prerequisite: Acct. 52.

316. Financial Accounting II (3)
The sequel to Accounting 315, this course continues with intensive study of such topics as stockholders' equity, valuation and disclosure of leases and pensions, income tax allocation, changing prices, revenue issues, earnings per share, and complexities related to the statement of changes in financial position. Analysis and interpretation of financial statements and problem-solving skills are integral parts of the course. Prerequisite: Acct. 315.

317. Advanced Financial Accounting (4)
A study of specialized topics in financial accounting, including partnership accounting, business combinations and consolidated financial statements, segment and interim reporting, foreign currency transactions and translation, and accounting and reporting for governmental and other nonprofit organizations. Involves considerable problem-solving and critical evaluation of controversial theoretical issues. Prerequisite: Acct. 315 or 316.

320. Fundamentals of Auditing (3)
An introduction to auditing theory, objectives, and practices related largely to the responsibilities of independent professional accountants. The auditing environment, generally accepted auditing standards, internal control theory, and reporting alternatives are considered. Exposure to operational auditing is provided. Prerequisites: Acct. 311 and 315.

324. Cost Accounting (3)
An in-depth study of cost concepts appropriate for product costing in a manufacturing operation, planning and controlling routine operations, and nonroutine decision-making. Topics include job order and process costing, joint and by-products, cost allocation, budgeting, standard costing, direct costing, cost-volume-profit analysis, and relevant costs for decisions. Prerequisite: Acct. 52.

371. Directed Readings (1-3)
Readings and research in various fields of accounting; designed for superior students who have a special interest in some topic or topics not covered by the regularly rostered courses. Written term paper(s) required. Prerequisite: preparation acceptable to the department chairperson.

372. Special Topics (1-3)
Special problems and issues in accounting for which no regularly scheduled course work exists. When offered as group

study, coverage varies according to interests of the instructor and students. Prerequisite: preparation in accounting acceptable to the department chairperson.

390. Internship (1-6)
Designed to give advanced students of accounting, who have maintained a satisfactory standard of scholarship and who show promise in the field of accounting, an opportunity to acquire field experience and training with selected industrial or public accounting firms or governmental agencies as a complement to the academic learning process. Outside readings are assigned. Written reports are submitted by students and a performance evaluation is made by the employer. The amount of credit is influenced by the length of the training period. Prerequisite: junior standing and approval of the faculty committee on internship.

Graduate Courses in Accounting

Undergraduates may wish to plan a program that includes the M.B.A. degree as part of the professional accounting preparation. For information about C.P.A. requirements in different states, the C.M.A. certificate, or for the selection of accounting electives, consult the department chairperson.

403. Financial Flows and Accounting Measurements (3)
Corporate financial reporting: identification, accumulation and communication of financial information to management and other users. Generally accepted accounting principles, uses and limitations of accounting information, asset valuation, income determination, funds flows, and analysis and interpretation of financial statements.

413. Managerial Accounting and Decision-Making (3)
Cost accounting techniques for management planning and control. Responsibility accounting, budgeting, cost behavior, cost estimating, and allocation, product costing, relevant costs, cost variance analysis, information requirements. Prerequisite: Acct 403 or equivalent.

421. Information Systems for Managers (3)
Information processing, computer, and data structure concepts in producing information. Communications between user management and data processing management in the systems development process. Control of systems development activities, data based systems, and distributive processing systems. Projects and case studies.

431. Accounting Theory and Thought (3)
Ciritical and historical examination of modern accounting concepts. Measurement, communication, and interpretation of enterprise income, capital, and related economic data. Prerequisite: 15 credit hours of accounting.

433. (IE 408) Management Information Systems (3)
Integrated and total systems concepts for organizational data bases and information systems as applied to planning, development and implementation of computer-based management information systems. Emphasis placed on the interaction of information systems with management planning and control. Prerequisite: an advanced course in information systems and a knowledge of programming.

435. Advanced Management Accounting (3)
Managerial planning and control problems with emphasis on the responsibilities of the accountant. practical applications using cases. Includes advanced treatment of management control systems, managed costs, transfer pricing, and the capital investment problem. Prerequisite: Acct 413 or a course in cost accounting.

439. Contemporary Issues in Financial Reporting (3)
Corporate financial reports from the perspective of the user-analyst: disclosure, price level accounting, foreign currency, business combinations, leases, and analysis of financial statements. Case studies. Prerequisite: Acct 413.

471. Directed Readings (1-3)
An extended study of an approved topic in the fields of accounting. May be repeated.

472. Special Topics (1-3)
Special problems and issues in accounting and law for which no regularly scheduled coursework exists. When offered as group study, coverage varies according to interests of the instructor and students. Prerequisite: preparation in accounting acceptable to the department chairman. May be repeated.

Administration and Supervision

See listings under Education.

Aerospace Studies

Professor. Col. W. David Kauffman, M.P.A. (Golden Gate), *chairperson.*
Assistant professors. Capt. Joseph B. Amejka, Jr., M.S. (Utah); Capt. Richard W. Booth, Jr., M.S. (S.U.N.Y.); Capt. Jane A. Robinson, M.B.A. (Wright State).

The Air Force Reserve Officer Training Corps (AFROTC) program at Lehigh was established in 1946. The program is conducted through the department of aerospace studies, which offers two voluntary programs, one of four years and one of two years, for students to qualify for a commission as a second lieutenant in the Air Force.

The general objective of the Air Force program is to instill in each student a basic understanding of associated professional knowledge, a strong sense of personal integrity and individual responsibility, an appreciation of the requirements of national security, and an opportunity to learn and develop leadership ability. The academic courses are available to all Lehigh students whether or not they want a commission.

Course credit. Advanced aerospace studies course credit may be substituted for six hours of electives for students in the College of Arts and Science and in the College of Business and Economics. In the College of Engineering and Applied Science, six credit hours are awarded in the normal program for a degree, but not within the "minimum" program.

Minor in Aerospace Studies

This program is designed to prepare an individual for commissioning as a second lieutenant in the U.S. Air Force and serve as an Air Force officer upon graduation. It is a required program for any Lehigh student who plans to receive a commission in the Air Force through AFROTC. The minor recognizes two basic needs of Air Force officers: familiarization with mathematical concepts required in the increasingly complex technological environment of national defense, and the officer as a manager and leader who must be able to effectively communicate with others.

The minor in aerospace studies includes the following courses:

AF 11, 12	The Air Force Today (2)
AF 13, 14	The Development of Air Power (2)
AF 101	Field Training (0)
AF 113, 114	Air Force Management and Leadership (6)
AF 115, 116	National Security Forces in Contemporary American Society (6)
Engl 1, 2	Composition and Literature and Literature: Fiction, Drama, Poetry (6)
Math 21	Analytic Geometry and Calculus I (4)
	total credit hours 26 (25)

Engl 10, 14 or 16 may replace Engl 2.

Math 31 (4 credit hours), Math 41 (3), or Math 388 (3) may replace Math 21. Other mathematical reasoning courses may be substituted with the approval of the department chairperson.

A maximum of six credits in aerospace studies courses may be included in the credits required for graduation.

Advanced credit granted by Lehigh for any of the required courses listed above will be credited toward the minor. A minimum grade of C must be earned in each course for the student to be eligible for designation as a distinguished graduate. The department of aerospace studies monitors the minor.

Four-Year Program

The four-year program consists of classroom and laboratory work during the four undergraduate years and four weeks of field training, usually between the sophomore and junior years, at an Air Force base.

During the General Military Course, the first two years, the program acquaints students with Aerospace history, the mission and organization of the Air Force, including technological advances and current research and development activities. Students also begin leadership training. During the Professional Officer Course, the last two years, the role of the armed forces in American society is examined. Emphasis is placed on personal development as a manager and a leader. Students develop leadership talents and abilities by assuming positions of responsibility in the Cadet Corps.

In addition to completing the required Aerospace Studies courses, General Military Course contract cadets must successfully complete a course in English composition within two academic years. They also are encouraged to take a course in speech during this period. Professional Officer Course cadets must successfully complete a mathematical reasoning course.

Two-Year Program

All requirements for commissioning can be completed in the two-year program. Students may apply for entry if they intend to complete two or more full academic years either undergraduate, graduate, or a combination of both. Prior to formal enrollment, each student successfully completes a six-week summer training period which replaces the General Military Course and the normal four-week summer training. Students in the two-year program also must meet the same English and mathematics requirements as students in the four-year program.

Scholarship Program

Air Force ROTC awards scholarships at the freshman, sophomore and junior levels. They are available to qualified cadets in the two-year and four-year programs. Scholarships are given on a semester basis. The maximum is eight semesters (four years), the minimum four semesters (two years). Scholarships of seven, six and five semesters are also available. The only requirement for scholarship eligibility is enrollment in the Aerospace Studies course. Commitment is not effective until acceptance of the scholarship or entrance into the advanced course. Once awarded a scholarship a cadet continues on scholarship status until completion of the advanced course if all academic and military requirements are met. Scholarships pay tuition (full or partial) and most textbook, laboratory, and incidental fees plus $100 a month nontaxable allowance during the school year. Scholarship recipients are required to complete one full year of a foreign language.

Commissioning Requirements

To be eligible for the Air Force ROTC advanced program (final two years), and commissioning, a student must be a citizen of the United States, physically qualified for commission in the Air Force in accordance with existing Air Force regulations, not under fourteen years of age and, upon graduation, not more than thirty years of age. For those with prior military service, commissioning must occur not later than age 35.

In addition, cadets must pursue work leading to at least a bachelor's degree and be willing to sign a formal agreement at the beginning of the advanced course or upon initiation of a college scholarship. The agreement, an enlistment into the Air Force Reserve, obligates the student to remain in the ROTC program, accept a commission and serve the required period in the Air Force upon graduation.

Aerospace Studies Courses

11. The Air Force Today (1) fall
A study of the doctrine, mission and organization of the U.S. Air Force. A study of tactical and airlift forces, their mission, function, and employment.

12. The Air Force Today (1) spring
A study of U.S. strategic offensive and defensive forces, aerospace support forces, and a review of Army, Navy and Marines general-purpose forces.

13. The Development of Air Power (1) fall
An examination of the developmental growth of air power from the advent of the air age to the conclusion of World War II by reviewing the various concepts of employment and focusing upon the factors which prompted research and technological change.

14. The Development of Air Power (1) spring
A continuation of AF 13 from the conclusion of World War II to the present, with emphasis on a variety of events and elements in the history of air power, especially where these provide significant examples of the impact of air power on strategic thought.

101. Field Training (0) summer
In order to receive a commission through Air Force ROTC, a student attends field training, normally during the summer following the sophomore year. Sessions include career and job orientation, organization and function of an Air Force base, junior officer training, physical training, small arms marksmanship, and survival. Travel pay is provided. Students receive approximately $100 per week in addition to room and board.

102. Advanced Training Program (0) summer
An honors program, highly recommended but not required to receive a commission. ATP is a two-or three-week orientation program on an Air Force installation, normally taken the summer prior to the final year by those with high academic standing. The program provides specialized career orientation and an opportunity to observe a working Air Force facility. The program provides contact with officers working in the student's specialty. Transportation, lodging and meals are provided in addition to approximately $100 per week.

Airborne Training Program (0) summer
Appropriate classroom, physical conditioning, and airborne parachute training (including five controlled parachute jumps) are available through a cooperative Air Force-Army program similar to that offered Air Force Academy cadets. Aerospace studies students volunteering for this course spend the summer preceding their final year in AFROTC. This is not required training. Prerequisite: AF 101.

113. Air Force Management and Leadership (3) fall
AF 113 and 114 are integrated management courses emphasizing the individual as a manager in an Air Force milieu. Individual motivation and behavioral processes, leadership, communications, and group dynamics are covered to provide a foundation for the development of the junior officer's professional skills. Organizational and personal values, management of forces in change, organizational power, politics, and managerial strategies and tactics are discussed. Actual Air Force cases are used.

114. Air Force Management and Leadership (3) spring
A continuation of AF 113.

115. National Security Forces in Contemporary American Society (3) fall
AF 115 and 116 conceptually focus on the armed forces as an integral element of society, with an emphasis on the broad range of American civil-military relations and the environmental context in which U.S. defense policy is formulated and implemented. In each semester, students prepare individual and group presentations for the class, write reports and participate in group discussions, seminars and conferences.

116. National Security Forces in Contemporary American Society (3) spring
A continuation of AF 115.

American Studies

American Studies Committee. William G. Shade, Ph.D. (Wayne State), *professor of history and director of American Studies;* Nicholas Adams, Ph.D. (N.Y.U.), *professor of art and architecture;* David Curtis Amidon, Jr., M.A. (Penn State), *lecturer in urban studies;* Peter G. Beidler, Ph.D. (Lehigh), *Lucy G. Moses Distinguished Professor of English;* Joseph A. Dowling, Ph.D. (N.Y.U.), *distinguished professor of history;* Alice L. Eckardt, M.A. (Lehigh), *associate professor of religion studies;* James R. Frakes, Ph.D. (Pennsylvania), *Edmund W. Fairchild Professor of American Studies;* Edward J. Gallagher, Ph.D. (Notre Dame), *professor of English;* Lawrence H. Leder, Ph.D. (N.Y.U.), *professor of history;* James R. McIntosh, Ph.D. (Syracuse), *professor of sociology;* Howard R. Whitcomb, Ph.D. (S.U.N.Y. at Albany), *professor of government.*

American Studies is an interdepartmental major emphasizing the idea that the institutions and values of a society comprise a whole, not merely the sum of its parts. By concentrating on the unique expressions of individuals contained in both the arts and popular culture and by studying the historical movements and contemporary institutions within which these expressions develop, American Studies reveals relationships that may not be clearly seen within the framework of a single discipline.

The broad interdisciplinary nature of American Studies equips the student with a well-rounded general education and a wide range of career opportunities. The student may choose to emphasize American history or literature to provide an excellent preparation for graduate school in these areas as well as in American Studies. In addition the major can be combined with other majors, such as journalism, or minors, such as Law and Legal Institutions, to furnish a sound underpinning for careers in those areas. With suitable collateral courses, the major also can prepare students for advanced work in museum administration, library science, social work and for teaching in both secondary schools and community colleges.

The major consists of fifteen credit hours of preliminary courses dealing with American literature, history, and popular culture. All students are also required to take two American Studies courses, one at the intermediate level introducing the general approach of the major and a senior seminar on contemporary American civilization. In connection with the director of American Studies, who serves as the adviser for the major, each student chooses a program of fifteen semester hours of upper-level courses drawn from four different groups. The major requirements total 36 credit hours.

required preliminary courses (15 credit hours)

Hist 9	Survey of American History I (3)
Hist 10	Survey of American History II (3)
Engl 23	American Literature (3)
Engl 24	American Literature (3)

Choose three hours in the area of American Popular Culture from the following:

Engl 63	Narrative Film (3)
Engl 89	Science Fiction (3)
Engl 189	Popular Literature (1-3)
Engl 191	Special Topics (1-3)

required American Studies courses (6)
Intermediate level: Arts 111, The American Character (3)
Upper-level seminar: Arts 311, Themes in Contemporary American Civilization (3)

required upper-level courses (15)
Choose at least six hours each from two groups.

Literature

Engl 376	Early American Literature (3)
Engl 377	American Romanticism (3)
Engl 378	American Realism (3)
Engl 379	Twentieth-Century American Literature (3)
Engl 380	Contemporary American Literature (3)
Engl 382	Themes in American Literature (3)

History

Rel 53	Religion and the American Experience (3)
Hist 119	Colonial America (3)
Hist 120	Revolutionary America (3)
Hist 325	American Social History, 1607-1877 (3)
Hist 326	American Social History Since 1877 (3)
Hist 327	American Intellectual History (3)
Hist 328	American Intellectual History (3)

Government and Society

Govt 317	The American Presidency (3)
Govt 327	Socialization and the Political System (3)
Govt 351	Constitutional Law (3)
US 321	White Protestant Americans (3)
Soc 141	Social Deviance (3)
Soc 364	Lifestyle and the Family (3)
Soc 370	Juvenile Delinquency (3)

Minorities in America

US 125	American Ethnic Groups (3)
US 328	The American Jewish Community (3)
Engl 311	Literature of Women (3)
Engl 312	Jewish Literature (3)
Engl 316	The Indian in American Literature (3)
Engl 319	The Black in American Literature (3)
Hist 131	The Black Experience in America (3)
Hist 124	Women in America (3)
Anth 182	North American Indians (3)

The courses listed here are recommended, but comparable courses in each of these areas may be substituted with written permission of the director of American Studies.

Admission to honors in American Studies is by invitation of the committee in the student's junior year. The student must attain an average of 3.2 in major courses in addition to the university honors requirements.

Anthropology

See listings under Social Relations.

Applied Mathematics and Statistics

Professors. Edward F. Assmus, Jr., Ph.D. (Harvard); Bennett Eisenberg, Ph.D. (M.I.T.); B. K. Ghosh, Ph.D. (London); Samuel L. Gulden, M.A. (Princeton); Gregory T. McAllister, Ph.D. (Berkeley), *head;* George E. McCluskey,

Ph.D. (Pennsylvania); Erie P. Salathe, Ph.D. (Brown); Murray Schechter, Ph.D. (N.Y.U.); Gerald F. Smith, Ph.D. (Brown); Gilbert A. Stengle, Ph.D. (Wisconsin).
Associate professors. Jacob Y. Kazakia, Ph.D. (Lehigh); Ramamirtham Venkataraman, Ph.D. (Brown).
Assistant professors. Wei-Min Huang, Ph.D. (Rochester); Charles H. Voas, Ph.D. (Virginia); Daniel J. Yaniro, Ph.D. (Northwestern); Joseph E. Yukich, Ph.D. (M.I.T.).

The Division of Applied Mathematics and Statistics was established within the Department of Mathematics to promote and administer undergraduate and graduate education in applied mathematics and statistics, and to foster interdisciplinary research in the mathematical sciences at Lehigh. Courses and programs offered by the Division may be found under the departmental listing.

Apprentice Teaching

The apprentice teaching program is designed to benefit juniors and seniors who wish to learn about teaching under the guidance of an experienced teacher. Apprentices often do a limited amount of lecturing or leading of discussions, assist in making up and evaluating written assignments and are available for individual consultation with students.

To participate in the apprentice teaching program a student must:

1. Have an over-all cumulative grade point average of 2.80 or better;
2. Have a cumulative grade point average of at least 3.32 and have completed at least two courses in the major field in which apprentice teaching is done and;
3. Have previously taken for credit the course or its equivalent in which the apprentice teaching will be done.

A student may roster for apprentice teaching only once each semester, only once in a given course, and only twice during a college career.

To register for apprentice teaching each student-teacher partnership will submit a preliminary contract of duties and obligations for approval of the department chair and the dean of the college in which the course is taken. This form must be submitted before the first day of classes in the semester. To complete the course, the apprentice teachers will submit written reports of their experiences to the central office coordinator in the Office of the Provost.

300. Apprentice Teaching (3)
Supervised participation in various aspects of the teaching of a course. Transcript will identify department in which apprentice teaching was performed. Prerequisite: Consent of department chairperson.

Art and Architecture

Professors. Richard J. Redd, M.F.A. (Iowa); Ricardo Viera, M.F.A. (R.I.S.D.), *director of Lehigh University Art Galleries.*
Associate professors. Nicholas Adams, Ph.D. (N.Y.U.), *chairman;* Ivan Zaknic, M.Arch. (Princeton)
Assistant professors. V. Tuncer Akiner, Ph.D. (Univ. of Sydney); Lucy Gans, M.F.A. (Pratt); Steven R. Van Gorp, M.Arch. (Washington).
Adjunct lecturers. Laurence Fink; Christine Ussler-Trumbull, M.Arch. (Columbia).

The department of art and architecture offers two major programs:

The architecture major is a multidisciplinary major based in the department that draws on the resources of all Lehigh's colleges. Although architectural design is the primary concern of this major (beginning students should take Arch 1 and Arch 43) courses in architectural history, history, social sciences and engineering are recommended.

The architecture major leads to the liberal arts B.A. (bachelor of arts), a four-year degree. This degree is satisfactory for admission to graduate study in architecture and candidacy for the M.Arch. professional degree or for planning, preservation, or history of architecture.

In recent years students have gone on to graduate study in architecture at Yale, Harvard, Penn, Columbia and Washington University, among other schools, or to entry-level employment in the profession.

Double majors with Urban Studies are quite frequent and the Arts/Engineering five-year degree, in which the student earns both B.A. (architecture) and B.S. (civil engineering), is available. For engineering students considering graduate study in architecture or an entry level position in an architectural-engineering firm an architecture minor is generally appropriate.

A major in art introduces the student to the basic media of art such as drawing, sculpture, printmaking, painting, and photography. For those interested in becoming a creative artist, intensive study at Lehigh as well as the other Lehigh Valley colleges is recommended; such a student can expect to take more than the required number of credits for the major.

A major in art can also be combined with psychology for those who seek a career in art therapy. It may also be combined with theater for those interested in costume design or with architecture and theater for those interested in set design. A major in art and minor in education is available for students interested in becoming public school art teachers.

A special track is available within the art major for students interested in art history.

The resources of the Lehigh University art collection are made available to many students taking classes in art. Prints, photographs, and paintings are often brought into the classroom and visits to art exhibitions on campus and elsewhere in the Lehigh Valley are a common part of art instruction.

Through the facilities of the Lehigh University art galleries, it is possible to see first-rate works of art on a regular basis. The annual contemporary art show is a special event. Several major museums are within easy traveling distance and the department runs regular bus trips to New York City. An annual lecture series has brought architects and artists to campus. In recent years Rodolfo Machado, Charles Gwathmey, Klaus Herdeg, Edmund Bacon, Steven Peterson, Thomas Armstrong, Rev. Howard Finster, Joyce Kozloff, Jonas Dos Santos, Geno Rodriguez, Harold Edgerton, Peter Berg, Jody Pinto have appeared at Lehigh. Cooperation with Moravian College allows students to register for art courses not offered at Lehigh, such as ceramics.

In addition to these two major programs, individually structured programs may be planned, such as art with an emphasis on architectural design, art history with an emphasis on museum training, and architecture with an emphasis on planning, urban studies, graphic communication, or government.

Minor programs may be established in architecture, art, graphic communication, and museum studies with a member of the department. Course requirements are specified, and a list of courses acceptable for the minors is available in the department.

Art Major

Forty-two credit hours are required

required preliminary courses (21 credit hours)

Art 5	Introduction to the Visual Arts (3)
Art 7	Studio Art Fundamentals (3)
Art 11	Drawing I (3)
Art 13	Sculpture I (3)
Art 20	Color (3)
Art 211	Drawing II (3)
Art 220	20th-Century Art (3)

plus one of the following:

Art 65	Perception and the Visual Arts (3)
Art 82	Art and Archaeology of Greece (3)
Art 111	Women in Art (3)
Arch 210	20th-Century Architecture (3)
Art 219	19th-Century Painting (3)

six required major courses (18 credit hours)
Art studio: six courses, two at the advanced level

Students interested in an art history concentration should substitute two preliminary studio courses with Art 1 and Art 2 or Arch 1. For the six required courses in art studio, courses in art history and museum studies should be substituted in consultation with an adviser. In order to complete an art history concentration students may be required to take courses in other LVAIC institutions.

Architecture Major

Sixty-two credit hours are required.

required preliminary courses (29 credit hours)

Arch 1	Architectural History (3)
Arch 43	Architectural Design I (4)
Art 11	Drawing I (3)
Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Laboratory I (1)
	two art studio courses (6)

required major courses (24 credit hours)

Arch 143	Architectural Design II (6)
Arch 210	20th-Century Architecture (3)
Arch 243	Architectural Design III (6)
Arch 343	Architectural Design IV (6)

plus one other course in architectural history (3)

three of the following (9 credit hours)

Arch 204	Ancient City and Society (3)
Arch 207	Renaissance Architecture (3)
Arch 209	Architecture 1750-1880 (3)
Arch 213	The City (3)
Arch 342	Architectural Theory (3)
Art 201	Archaeology: Lands of the Bible (3)
Anth 128	Urban Ethnology (3)
Anth 335	Religion, Symbolism and Cosmology (3)
Eco 311	Environmental Economics (3)
Eco 312	Urban Economics (3)
Hist 333	American Urban History to 1885 (3)
Hist 334	American Urban History, 1880 to Present (3)
Phil 123	Aesthetics (3)
Psyc 373	Sensation and Perception (3)
US 363	Philadelphia: Development of a Metropolis (3)

For students contemplating graduate studies in architecture, Mech 1 and Mech 11 are recommended.

Also recommended is that students fulfill the foreign language and culture option with a foreign language.

Undergraduate Courses in Art

Art 1. Introduction to Art History I (3) summer
Development of painting and sculpture primarily in the Western tradition from paleolithic to the Renaissance. Redd

Art 2. Introduction to Art History II (3) summer
Painting and sculpture primarily of Western civilization from the 16th Century to modern times. Redd

Art 5. Introduction to the Visual Arts (3) spring
Principles of visual expression. Examples of art from various periods are examined in relation of their historical and cultural context, to their plastic organization and their significance as reflection of human experience. Redd, Gans

Art 7. Studio Art Fundamentals (3) fall
The exploration and organization of form as the fundamental component of design and drawing. Students are guided through projects in visual expression introducing them to principles utilizing line, shape, color, texture, value and mass in a variety of mediums. Redd

Art 11. Drawing I (3) fall-spring
Concepts and practice of drawing, both traditional and contemporary. Includes drawing from life and an introduction to materials and techniques. Gans

Art 13. Sculpture I (3)
Projects directed toward developing design in sculpture. Exploration of materials and their application. Emphasis on sculptural form as it relates to techniques. Gans

Art 20. Color (3) spring, alternate years
Projects directed toward building an awareness of color. Study and observation of the dynamics of color in theory and practice. Redd

Art 23. Life Drawing I (3)
Drawing form the live model as the fundamental experience leading toward an analysis of form in light and space. Emphasis on developing self-expression and on the methods and media of drawing. Gans

Art 37. Printmaking I (3)
A structured course in mono print, relief 'block' printing and basic etching. Introducing materials and tools, stressing creative application and the conceptual aspects of the media. Prerequisite: Art 11. Redd

Art 43. Graphic Communication I (3) fall
Introduction to basic principles of visual communication that guide the development of creative solutions in graphic, printing, public relations, advertising design. Viera

Art 65. (Psyc 65) Perception and the Visual Arts (3)
Perceptual and cognitive theories and principles as related to visual fine arts and aesthetic experience. Shortess

Art 77. Photography I (2)
Introduction to photography as a fine art. Emphasis on interaction of technique, perception and communication in making and responding to photographic image. Lectures, demonstrations, critiques. Students must provide own hand camera. Prerequisite: consent of the chairperson. Fink

Art 82. (Clss 82) Art and Archaeology of Greece (3)
The art and architecture of ancient Greece as revealed by archaeology. Brief surveys of the political and cultural backgrounds to the various artistic periods: Bronze Age, Geometric, Orientalizing, Classical, Hellenistic and Roman. Lectures, Slides and films.

Art 111. Women in Art (3)
Survey of works and lives of women artists from the Renaissance to the present; changing role of women in relation to the art establishment. Visits to museums and artists' studios. Gans

Art 113. Sculpture II (3)
Development of principles and techniques in Sculpture I. Modeling, casting, fabrication and carving. Emphasizes an approach to sculptural form and an exploration of the evolution of modern sculpture. Gans

Art 123. Life Drawing II (3)
Advanced drawing from the live model. Prerequisite: Art 23. May be repeated for credit. Staff

Art 135. Painting I (3)
Painting in oil or acrylic oriented toward developing individual creative expression combined with an understanding of the physical nature of the materials. Studio prerequisite: Art 7, 11 or 20, or consent of department chairman. Staff

Art 138. Printmaking II (3)
Principles of Intaglio printing: drypoint and etching. Introduction to silk screen printing. Lithography option. Redd

Art 143. Graphic Communication II (3) spring
Aspects of design are inter-related in function, concept or planning processes. Course emphasizes creativity and problems and soltions in visual communication. Workshops, team work, critiques, conferences. Prerequisite: Art 43 or consent of department chairman. Viera

Art 177. Photography II (2)
Intensive work in photography as fine art. Advanced study of problems of the photographic images. Lectures, demonstrations, critiques. Students must provide own hand camera. Prerequisite: Art 77. Fink

Art 179. History of Photography (1)
Photography as fine art from earliest images to present day. Problems in contemporary photography. Fink

Art 201. (Clss 201) Archaeology: Lands of the Bible (3)
Chronological survey of archaeological finds from Palaeolithic, Neolithic, Bronze Age, Iron Age, and later cultures in the Near East. Material illustrating the cultures and events of the Bible.

Art 211. Drawing II (3)
Projects in creative drawing designed to build on concepts and practices initiated in basic drawing and life drawing. May be repeated for credit. Prerequisite: Art 11 and 23. Gans

Art 219. 19th-Century Painting (3)
From Neoclassicism through the sequential movements of Romanticism, Naturalism, Impressionism, and Post-Impressionism in art of Europe and the United States. Redd

Art 220. 20th-Century Art (3)
The development of 20th-Century painting and sculpture from the foundations laid by Cezanne and Van Gogh through the revolutionary movements of cubism, expressionism, surrealism, abstract expressionism, and Pop. Illustrated lectures. Redd

Art 222. Seminar in Contemporary Art (3)
Recent aspects, developments in contemporary art. Exploring ideas and consequences of today's image-making. Studio workshops, readings, discussions and museum visits. Prerequisite: Art 2 or 5. Staff

Art 231. Advanced Design (3)
Directed projects and preparation of portfolio for advanced students in Studio Art and Graphic Communication. Prerequisite: Art 20, 113 or 143. Staff

Art 235. Painting II (3)
Problems in oil, watercolor, acrylic and mixed media. Prerequisite: Art 135.

Art 237. Printmaking III (3)
Directed project work which allows the student to pursue in greater depth specified printmaking processes in intaglio, relief, collagraph or silk screen. Working in larger scale. Greater technical demand. Prerequisite: Art 37 or 138. Redd

Art 269. Special Topics in Art History (3)
Directed projects for advanced students in the history of art or architecture. Prerequisite: consent of the department chairman. Staff

Art 273. Special Topics in Studio Practice (1-4)
Individually directed projects for advanced students capable of undertaking independent creative work in applied art and photography. Prerequisite: consent of the department chairman. Staff

Art 321. Graphic Arts Internship (1-4)
Practical in-field experience in graphic communication and graphic arts. Prerequisites: Art 143 and permission of chairman.

Art 335. Painting III (3)
Prerequisite: Art 235 or consent of the department chairman. May be repeated for credit. Staff

Art 337. Printmaking Workshop (3)
Independent experimentation and work in a chosen graphic media for the advanced student. Photographic applications, conceptual problems and mixed media. Conferences and critiques. May be repeated for credit. Prerequisite: Art 237 or consent of the department chairman. Redd

Undergraduate Courses in Architecture

Arch 1. Architectural History (3)
A survey of major monuments from the Pyramids to Post-Modernism. Works seen in context of development of design concepts, relation to structural change. Slide lectures. Field trips. Adams

Arch 43. Architectural Design I (4)
Fundamental design studio for potential architecture majors or minors. Two and three dimensional design with emphasis on form, space, function, color, and materials. An exploration of conceptualization, process, product, intention, and self-expression. Van Gorp

Arch 103. (Clss 103) Archaeology of Italy (3)
Neolithic, Terramaran, Villanovan and Etruscan cultures. Rome the city: its buildings, monuments and streets, through the kingdom, republic, and empire. Survey of Pompeii, Herculaneum and Ostia. Lectures, readings and reports.

Arch 143. Architectural Design II (6)
Continuation of Arch 43. The design of small buildings with emphasis on drawing and modelling. An exploration of the evolution of architectural form and space, function, intention and meaning, as well as historical precedents and aesthetics. Previous or concurrent courses in studio art and architectural history, especially Arch 1 are strongly recommended. Prerequisite: Arch 43. Van Gorp, Zaknic

Arch 204. (Clss 204) Ancient City and Society (3)
Ancient theories of city and city planning; attitudes to life in the city; rise of urban civilization from Neolithic prototypes through the Near East, Egypt, Greece, and Rome; insights applicable to current urban problems.

Arch 206. The Gothic Cathedral (3)
The architectural form and social context of medieval ecclesiastical architecture in Europe; emphasis on the cathedrals of Chartres, Paris, Amiens, and Reims. Adams

Arch 207. Renaissance Architecture (3)
History of architecture and urban form during the Italian Renaissance. Major architects (Brunelleschi to Palladio), building types (church, palace, and fortress), and urban centers (Pienza, Rome, and Venice). Adams

Arch 209. Architecture 1750-1880 (3)
From the industrial revolution to the skyscraper. The nature of industrial architecture and its effect on cities and city planning. Emphasis on France, England, Germany, and America. Adams

Arch 210. 20th-Century Architecture (3)
History and theory of architecture from 1880. Emphasis on Frank Lloyd Wright, Le Corbusier, and Mies Van der Rohe, and the problems of contemporary design. Zaknic

Arch 213. The City (3)
Historical development of urban design and the city. City planning as a response to topography, war and human needs. From ancient world to modern times. Adams

Arch 243. Architectural Design III (6)
Continuation of Arch 143. The design of larger, more complex buildings with an emphasis on contextural, environmental, sociological, psychological, and constructional concerns. Prerequisite: Arch 1, 43, 143, and one art studio. Van Gorp, Zaknic

Arch 271. Special Topics in Architecture (1-4)
Directed projects for advanced students in architecture or architectural criticism. Prerequisite: consent of the department chairman. Staff

Arch 311. Portfolio (1)
The concept, layout, and preparation of a portfolio for graduate school application or employment search, including graphic techniques and reproduction methods. Prerequisite: Art 211 or Art 335 or Arch 243. Van Gorp, Viera

Arch 321. Architectural Internship (1-3)
Supervised internship in architectural firm, planning or preservation office. Internship plan must be approved in writing by chairman.

Arch 342. Architectural Theory (3)
Relations of architectural or urban history, theory, and practice. May be repeated for credit as topic varies.

Arch 343. Architectural Design IV (6)
Continuation of Arch 243. The design of buildings and building groups, with the emphasis on urban design and the city. Prerequisite: Arch 1, 43, 143, 210, 243 and one art studio. May be repeated for credit. Van Gorp, Zaknic

Arch 345. Architectural Design V (3)
Undergraduate thesis. An individual design project exploring, with faculty approval, some aspect of architecture of interest to the student. Prerequisite: Architectural Design I-IV; all other courses required for major, previously or concurrently.

Arch 351. Computer Aided Design I (3)
Use and role of computers in architecture. Digital computer, applications in an architecture office, geometric modeling, topology, design knowledge, knowledge engineering, using a micro computer aided design system in the design and drafting of buildings, structures. Prerequisite: Arch 143 or consent of chairman. Akiner

Arch 352. Computer Aided Design II (3)
Use of computer aided design as a tool to design and draft in the area of art, architecture and structures. Provides an advanced hands on experience both in the early and the detailed stages of design using a micro-CAD system. Prerequisite: Arch 351 or consent of chairman. Akiner

Museum Studies

Art 175. Introduction to Museum Work (3) fall-spring
Introduction to the methods and procedures of research on art objects, historical sites, and documents. The nature of museum work in its practical aspects. Field trips and workshops. Each student completes a research report or equivalent. Prerequisite: consent of the department chairman. Viera

Art 275. Museography and Museology (1-3) fall-spring
Theory and practice in contemporary museums and galleries. Research in the Lehigh University art collection. Curatorial problems in interpretation, display, cataloging and conservation. Each student completes a research report or equivalent. May be repeated for credit. Viera

Art 375. Internship (3) fall-spring
Internship under professional supervision in the principal museum areas: curatorship, conservation, exhibition, interpretation, and administration in association with the Lehigh University Art Galleries, Historic Bethlehem, Inc. and Lehigh County Historical Society. Prerequisite: Art 175, 275 and consent of the department chairman. May be repeated for credit. Viera

Arts and Science

1. Choices and Decisions (1)
Introduction to decision making with emphasis on curriculum, career planning, and social options. Techniques for using values, family history, and social norms as guidelines for decision making processes. Pass-fail grading.

11. Sex Roles and Society: Continuity and Change (3)
Interdisciplinary study of sex roles- their existing character and impact upon individuals and institutions: masculine and feminine social roles in fiction; historical attitudes toward marriage and men's and women's work; research on sex differences; ideals of sex equality.

111. The American Character (3)
A chronological and methodological analysis of the shifting conceptions of 'this new man, the American.' Readings are selected from foreign and domestic observers ranging from Crevoeur to Christopher Lasch. Special attention is given to the conceptual difficulties of analyzing national character and to the debate over such an analysis. Dowling

Arts-Engineering

G. Mark Ellis, Ph.D., associate dean, College of Arts and Science, *curriculum director.*

The standard major for arts-engineers working towards a bachelor of science degree is applied science. This includes all of the science and engineering courses required in the freshman year and included in the pattern roster for the chosen field of engineering.

Arts-engineers with special interests outside engineering frequently combine another arts or science major with their engineering program. Interested students should consult with the curriculum director.

Recommended freshman year. Arts-engineering freshmen have the same roster of courses as do engineering freshmen, with the exception that the arts-engineering freshman takes Eco 1 in the second semester in place of an elective. Refer to the recommended freshman year, page 36.

Recommended professional sequences. Beginning with the sophomore year, the arts-engineering student will be guided by the appropriate pattern roster in the chosen field. The pattern roster shows the most effective way of combining arts and engineering courses to prepare for the last year in the branch of engineering chosen.

Although the minimum number of credit hours needed for the bachelor of arts degree is 121, a student in arts-engineering should expect to earn more than this in order to qualify for the bachelor of science degree in the chosen field of engineering at the end of the fifth year. The number of credits needed for both degrees is shown for each pattern roster.

Arts-Chemical Engineering

A total of 165 credit hours are needed for the bachelor of arts and the bachelor of science degree. For the freshman year, see page 36. See electives (b) through (f) for the chemical engineering program on page 88.

Careful planning is required so that these may be scheduled during the senior year and fifth year of the program. Any order that does not violate prerequisites is acceptable.

sophomore year, first semester (17 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Chem 31	Chemical Equilibria in Aqueous Systems (3)
ChE 43	Introduction to Chemical Engineering (4)
	distribution electives (6)

sophomore year, second semester (16 credit hours)

Math 205	Linear Methods (3)
ChE 44	Chemical Process Analysis I (4)
Chem 187	Physical Chemistry I (3)
	distribution electives (6)

junior year, first semester (17 credit hours)

Chem 51	Organic Chemistry (3)
Chem 53	Organic Chemistry Laboratory (1)
ChE 141	Chemical Process Analysis II (4)
	distribution electives (9)

junior year, second semester (18 credit hours)

Chem 52	Organic Chemistry (3)
ChE 142	Chemical Process Analysis III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
	distribution electives (6)

senior year, first semester (17 credit hours)

Chem 189	Physical Chemistry II (3)
Chem 192	Physical Chemistry Laboratory (2)
	electives for engineering major (6)*
	distribution electives (6)

senior year, second semester (16 credit hours)

ChE 202	Chemical Engineering Laboratory I (3)
ChE 210	Chemical Engineering Thermodynamics (4)
	elective for engineering major (6)*
	distribution elective (3)

fifth year

See program description for senior year of chemical engineering.

*These electives are chosen with the chemical engineering adviser.

Arts-Civil Engineering

A total of 162 credit hours are needed for the bachelor of arts and the bachelor of science degrees.

sophomore year, first semester (17 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Mech 1	Statics (3)
Geol 101	Geology for Engineers (3)
CE 112	Surveying (4)
	distribution elective (3)

sophomore year, second semester (17 credit hours)

Math 205	Linear Methods (3)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
	distribution electives (9)

junior year, first semester (17 credit hours)

Mech 11	Mechanics of Materials (3)
CE 115	Probability and Statistics in Civil Engineering (2)
	distribution electives (12)

junior year, second semester (15 credit hours)

Mech 102	Dynamics (3)
CE 11	Engineering Graphics (2)
CE 17	Introduction to Computer Graphics (1)
Mat 92	Structure and Properties of Materials (3)
	distribution electives (6)

senior year, first semester (16 credit hours)

CE 117	Numerical Methods in Civil Engineering (2)
CE 121	Mechanics of Fluids (3)
CE 143	Soil Mechanics (4)
CE 159	Structural Analysis I (4)
CE 213	Engineering Economics (1)
	distribution elective (3)

senior year, second semester (17 credit hours)

CE 160	Structural Design (4)
CE 170	Environmental Engineering Flow Systems (3)
CE 214	Engineering Planning (3)
CE 222	Hydraulic Engineering (4)
	distribution elective (3)

summer

CE 100	Summer Employment (0)

Eight weeks of summer employment should precede the fifth year.

fifth year

See program description for senior year of civil engineering.

Arts-Computer Engineering

A total of 159 credit hours are needed for the bachelor of arts and the bachelor of science degrees. For the freshman year, see page 36.

sophomore year, first semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
CSc 33	Principles of Computer Engineering (4)
	distribution elective (3)

sophomore year, second semester (16 credit hours)

CSc 17	Structured Programming and Data Structures (4)
CSc 261	Discrete Structures (3)
Math 205	Linear Methods (3)
	distribution electives (6)

junior year, first semester (16 credit hours)

ECE 81	Principles of Electrical Engineering (4)
Math 231	Probability and Statistics (3) **or**
Math 309	Theory of Probability (3)
	distribution electives (9)

junior year, second semester (16 credit hours)

ECE 116	Software Engineering (3)
ECE 108	Signals and Systems (4)
	distribution electives (9)

senior year, first semester (14 credit hours)
ECE 121 Electronic Circuits Laboratory (2)
ECE 123 Electronic Circuits (3)
ECE 125 Circuits and Systems (3)
elective (3)
distribution elective (3)

senior year, second semester (14 credit hours)
ECE 138 Digital Systems Laboratory (2)
ECE 201 Computer Architecture (3)
approved elective* (3)
distribution electives (6)

fifth year

See program description for senior year of computer engineering.

*These electives require approval of the department of computer science and electrical engineering. They are subjects in the area of science and technology, not restricted to offerings of the department.

Arts-Electrical Engineering

A total of 158 credit hours are needed for the bachelor of arts and bachelor of science degrees. For the freshman year, see page 36.

sophomore year, first semester (15 credit hours)
Math 23 Analytic Geometry and Calculus III (4)
Phys 21 Introductory Physics II (4)
Phys 22 Introductory Physics Laboratory II (1)
distribution electives (6)

sophomore year, second semester (15 credit hours)
Math 205 Linear Methods (3)
technical elective (3)
distribution electives (9)

junior year, first semester (17 credit hours)
ECE 81 Principles of Electrical Engineering (4)
CSc 33 Principles of Computer Engineering (4)
Math 231 Probability and Statistics (3) **or**
Math 309 Theory of Probability (3)
distribution electives (6)

junior year, second semester (16 credit hours)
ECE 108 Signals and Systems (4)
approved elective* (3)
distribution electives (9)

senior year, first semester (14 credit hours)
ECE 121 Electronic Circuits Laboratory (2)
ECE 123 Electronic Circuits (3)
ECE 125 Circuits and Systems (3)
approved elective* (3)
distribution elective (3)

senior year, second semester (17 credit hours)
ECE 126 Physical Electronics (3)
ECE 136 Electromechanics Laboratory (3)
ECE 138 Digital Systems Laboratory (2)
ECE 202 Introduction to Electromagnetics (3)
approved elective* (3)
distribution elective (3)

fifth year

See program description for senior year of electrical engineering.

*These electives require approval of the department of computer science and electrical engineering. Approved electives are subjects predominantly in the area of science and technology. They are not restricted to offerings in the department. Students must choose at least one elective in mathematics, at least one elective in either materials, thermodynamics, fluid mechanics, or physical chemistry, and at least one elective in physics, chemistry, or biology.

Arts-Engineering Physics

A total of 161 credit hours are needed for the bachelor of arts and bachelor of science degrees. For the freshman year, see page 36.

sophomore year, first semester (15 credit hours)
Phys 21 Introductory Physics II (4)
Phys 22 Introductory Physics Laboratory II (1)
Math 23 Analytic Geometry and Calculus III (4)
distribution electives (6)

sophomore year, second semester (15 credit hours)
Phys 31 Introduction to Quantum Mechanics (3)
Math 205 Linear Methods (3)
distribution electives (9)

junior year, first semester 15 credit hours)
Phys 212 Electricity and Magnetism I (3)
Phys 215 Classical Mechanics I (3)
Math 322 Methods of Applied Analysis I (3)
distribution electives (3)
electives (3)

junior year, second semester 18 credit hours)
Phys 213 Electricity and Magnetism II (3)
Phys 190 Electronics (3)
Phys 362 Atomic and Molecular Structure (3)
distribution electives (6)
electives (3)

senior year, first semester (17 credit hours)
Phys 260 Laboratory Techniques (2)
Phys 216 Classical Mechanics II (3)
distribution electives (6)
electives (3)

senior year, second semester (17 credit hours)
Phys 261 Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phys 264 Nuclear and Elementary Particle Physics (3)
distribution electives (6)
electives (6)

fifth year, first semester (18 credit hours)
Phys 340 Thermal Physics (3)
electives (15)

fifth year, second semester (15 credit hours)
Phys 171 Physics Proseminar (1)
electives (14)

The electives include at least fourteen credit hours of approved technical electives, including two of the courses Phys. 363, 367, 369, 352 or 355, and 346 or 348 or 365. Students planning graduate work in physics are advised to include Phys. 273 and 369 among their electives.

Arts-Industrial Engineering

A total of 159 credit hours are needed for the bachelor of arts and bachelor of science degrees. For the freshman year, see page 36.

sophomore year, first semester (16 credit hours)
Math 23 Analytic Geometry and Calculus III (4)
Phys 21 Introductory Physics II (4)
Phys 22 Introductory Physics Laboratory II (1)
IE 111 Engineering Probability and Statistics (3)
IE 112 Computer Graphics (1)
distribution elective (3)

sophomore year, second semester (16 credit hours)
IE 121 Applied Engineering Statistics (3)
IE 122 Software Tools (1)
IE 124 Engineering Economy and Decision Analysis (3)
distribution electives (9)

junior year, first semester (15 credit hours)
Math 205 Linear Methods (3)
IE 221 Operations Research - Probabilistic Models (3)
Mat 63 Engineering Materials and Processes (3)
distribution electives (6)

junior year, second semester (16 credit hours)
IE 222 Operations Research - Deterministic Models (3)
ECE 81 Principles of Electrical Engineering (4)
distribution electives (9)

senior year, first semester (16 credit hours)
IE 115 Fundamentals of Modern Manufacturing (3)
IE 116 Manufacturing Laboratory (1)
engineering science elective (3)*
distribution electives (9)

senior year, second semester (16 credit hours)
IE 131 Work Systems and Facilities Planning (3)
IE 132 Work Systems and Facilities Planning Laboratory (1)
engineering science electives (6)*
electives (3)
distribution elective (3)

summer
IE 100 Industrial Employment (0)

fifth year

See program description for senior year of Industrial Engineering.

*Note: Engineering science electives must be approved by the department of industrial engineering adviser.

Arts-Mechanical Engineering and Mechanics

A total of 159 credit hours are needed for the bachelor of arts and the bachelor of science degrees. For the freshman year, see page 36.

sophomore year, first semester (16 credit hours)
Phys 21 Introductory Physics II (4)
Phys 22 Introductory Physics Laboratory II (1)
Math 23 Analytic Geometry and Calculus III (4)
ME 10 Graphics for Engineering Design (4)
distribution electives (3)

sophomore year, second semester (18 credit hours)
Mech 1 Statics (3)
Math 205 Linear Methods (3)
distribution electives (12)

junior year, first semester (15 credit hours)
ME 104 Thermodynamics I (3)
Mech 11 Mechanics of Materials (3)
distribution electives (9)

junior year, second semester (15 credit hours)
Mech 102 Dynamics (3)
ME 21 Mechanical Engineering Laboratory I (1)
ME 231 Fluid Mechanics (3)
ECE 81 Principles of Electrical Engineering (4)
ECE 162 Electrical Laboratory (1)
ME 105 Thermodynamics II (3)

senior year, first semester (15 credit hours)
Mat 63 Engineering Materials and Processes (3)
Math 208 Complex Variables (3) **or**
Math 231 Probability and Statistics (3)
Mech 203 Advanced Strength of Materials (3)
distribution electives (6)

senior year, second semester (18 credit hours)
ME 101 Mechanical Engineering Design 1 (2)
ME 151 Mechanical Elements (3)
ME 242 Mechanical Vibrations (3)
ME 121 Mechanical Engineering Laboratory II (1)
distribution electives (6)
elective (3)

fifth year

See program description for senior year of mechanical engineering & mechanics.

Arts-Materials Science and Engineering

A total of 164 to 166 credit hours are needed for the bachelor of arts and bachelor of science degrees, depending on the option selected. For the freshman year, see page 36.

sophomore year, first semester (16 credit hours)
Mat 63 Engineering Materials and Processes (3) **or**
Mat 93 Introduction to Solid State Materials (3)
Math 23 Analytic Geometry and Calculus III (4)
Phys 21 Introductory Physics II (4)
Phys 22 Introductory Physics Laboratory II (1)
Mat 10 Materials Laboratory (1)
distribution elective (3)

sophomore year, second semester (15 credit hours)
Mech 1 Statics (3)
Math 205 Linear Methods (3) **or**
Math 231 Probability and Statistics (3)
distribution electives (9)

junior year, first semester (15 credit hours)
Chem 207 Metallic Elements (3)
Mat 207 Crystal Structure and Atom Movements (3)
Mat 210 Metallurgical Thermodynamics (3)
Mech 11 Mechanics of Materials (3)
distribution electives (3)

junior year, second semester (15-16 credit hours)
Mat 208 Phase Diagrams and Transformations (3)
Mat 218 Mechanical Behavior of Materials (3)
ECE 81 Principles of Electrical Engineering (4) **or**
Phys 31 Introduction to Quantum Mechanics (3)
distribution electives (6)

senior year, first semester (15 credit hours)
Mat 307 Materials Engineering I (3)
ChE 60 Unit Operations Survey (3)
distribution electives (9)

senior year, second semester (18 credit hours)
Mat 101 Professional Development (2)
Mat 212 Electronic Behavior of Solids (3)
Mat 304 Chemical Metallurgy (4)
distribution electives (6)
elective (3)

summer
Mat 100 Industrial Employment

fifth year

See program description for senior year of materials science and engineering.

Note: Students interested in the industrial or research options should consult with the department chairperson prior to their fourth year. Students selecting the research option should elect Mat 240, Research Techniques, in the second semester of the senior year.

Arts-Master of Business Administration Program

The arts-master of business administration two-degree program is a special opportunity offered by the College of Arts and Science. See Section III for a description.

Asian Studies

The East Asian Studies minor program is an opportunity in the College of Arts and Science. A description of the program is found in Section III.

Astronomy

Professor. George E. McCluskey, Ph.D. (Pennsylvania), *head.*

Astronomy is offered in the department of mathematics.

1. The Solar System (3) fall
Survey of our knowledge of the solar system. Apollo lunar missions. Mariner missions to Mercury, Venus and Mars. Viking missions to Mars. Missions to Jupiter and Saturn.

2. Stellar Astronomy (3) spring
Survey of our knowledge of stars and stellar systems. Observation and theory of pulsars, quasars, X-ray sources, gamma-ray sources, neutron stars and black holes.

171. Readings (1-3) fall-spring
For nonscience majors to study an area of astronomy more deeply than at the introductory level. Individual supervision. Prerequisites: Astr 1 or Astr 2, and Math 21 or Math 31 or Math 41. May be repeated for credit with the consent of the division head.

211. Stellar Structure and Evolution (3) fall, even-numbered years
Physical processes in stellar interiors. Theory of stellar evolution and interpretation of observations. Binary star evolution. Theory of novae and supernovae. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21.

221. Stellar Atmospheres (3) fall, odd-numbered years
Observation and theory of stellar spectra. Model atmospheres and chemical abundances. Extended atmospheres, stellar winds and mass loss. Theory of gaseous nebulae. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21.

232. High-Energy Astrophysics (3) spring odd-numbered years
Observation and theory of X-ray and gamma-ray sources, quasars, pulsars, radio galaxies, neutron stars, black holes. Results from ultraviolet, X-ray and gamma ray satellites. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21.

242. Relativity and Cosmology (3) spring, even-numbered years
Special and general relativity. Schwarzschild and Kerr black holes. Supermassive stars. Relativistic theories of the origin and evolution of the universe. Prerequisites: Math 23 or Math 32 or Math 44, previously or concurrently, and Phys 21.

350. Topics in Astrophysics (3) fall-spring
For science or engineering majors who desire to study an active area of research in astrophysics. Individual supervision. Prerequisites: Astr 2, and Math 23 or Math 32. May be repeated for credit with the consent of the division head.

Biology

Professors. John H. Abel, Ph.D. (Brown), *chairperson;* Sidney S. Herman, Ph.D. (Rhode Island); Steven Krawiec, Ph.D. (Yale); Bland S. Montenecourt, Ph.D. (Rutgers); Jeffrey A. Sands, Ph.D. (Penn State)
Associate professors. Barry Bean, Ph.D. (Rockefeller); David Cundall, Ph.D. (Arkansas); Bruce R. Hargreaves, Ph.D. (Berkeley); Murray Itzkowitz, Ph.D. (Maryland); Hayden N. Pritchard, Ph.D. (Lehigh).
Assistant professors. Vassie C. Ware, Ph.D. (Yale); Craig E. Williamson, Ph.D. (Dartmouth).
Adjunct faculty. David G. Beckwith, Ph.D. (Lehigh); Elizabeth Chornesky, Ph.D. (Texas); Arthur E. Humphrey, Ph.D. (Columbia); Santo Longo, M.D. (Jefferson Medical College); John L. Palmer, Ph.D. (Brandeis); Janice A. Phillips, Ph.D. (Pennsylvania); Charles Wahle, Ph.D. (Johns Hopkins); Jayantha H. Wimalasena, Ph.D. (Colorado Medical School).

The Department of Biology offers three major programs: the Bachelor of Arts in Biology; the Bachelor of Science in Biology; and the Bachelor of Science in Molecular Biology. The B.A. program requires 28 hours of Biology courses as compared to 34 hours in each of the B.S. programs. The B.A. program requires completion of the College of Arts and Science distribution requirements, whereas the B.S. programs require completion of 30-34 hours of non-science courses including experience in both the Humanities and Social Sciences.

The B.S. programs are designed for pre-professional education, and include requirements commonly expected for post-graduate degree programs in the sciences. The B.A. program offers greater flexibility for the student to elect courses of interest in a variety of disciplines. Both B.S. and B.A. candidates should consult their academic advisers for course choices most appropriate to their post-graduate plans.

B.A. with Major in Biology

College and university requirements

Engl 1	Composition and Literature (3)
Engl 2, 4, 6, 8	Composition and Literature: Fiction,
or 10	Drama, Poetry (3)
A&S 1	Choices and Decisions (1)

Distribution Requirements (see page 27)

Major Program (45 credit hours)

Biology (28 credit hours)

Biol 21	Principles of Biology (3) *
Biol 22	Introduction to Biology Laboratory (1) *

Biol electives	(24 credit hours)

Mathematics (6 credit hours)

Math 41	BMSS Calculus I (3) *
Math 44	BMSS Calculus II (3) *

Chemistry/Physics (11 credit hours)

Chem 21	Introductory Chemical Principles (4) *
Chem 22	Chemical Principles Laboratory (1)*
Chem 51	Organic Chemistry (3)

and one of the following:

Chem 31	Chemical Equilibria in Aqueous Systems (3) **or**
Chem 194	Physical Chemistry for Biological Sciences (3) **or**
Phys 11	Introductory Physics I (4)

*Although no specific sequence is required, it is recommended that courses marked with an asterisk be completed during the freshman year.

The B.S. in Biology

The bachelor of science in biology offers broad scientific preparation in biology to facilitate entry into the life sciences. Progression through the program is best served through early commitment.

Requirements for the B.S. in Biology

College and university requirements (37 credit hours)

Engl 1	Composition and Literature (3)
Engl 2, 4, 6, 8 or 10	Composition and Literature: Fiction, Drama, Poetry (3)
A&S 1	Choices and Decisions (1)
Non-science electives	(30), to be broadly distributed in fields of thought other than natural sciences and mathematics, including at least 12 credit hours each in the humanities and social sciences.

Major Program (34 or 35 credit hours)

Biology

Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Biol 28	Mendelian and Population Genetics (3)
Biol 131 or Biol 132	Non-Vascular Plants (3) **or** Evolution of Vascular Plants (3)
Biol 133 or Biol 134	Invertebrate Zoology (3) **or** Comparative Vertebrate Anatomy (4)
Biol 211	Ecology (3)
Biol 220 or Biol 223	Cell Physiology (3) **or** Animal Physiology (3)
Biol 317	Evolution (3)
Biol 235	Microbiology (3)
	Biol electives (9)

Mathematics (12 credit hours)

either

Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12)

or

Math 41, 44, 42, 43	BMSS Calculus I, II, Probability and Linear Algebra (12)

Collateral Sciences

Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Laboratory (1)
Chem 51, 52	Organic Chemistry (6)
Chem 55	Organic Chemistry Laboratory (2)
Chem 31	Chemical Equilibria in Aqueous Systems (3)
Chem 187 or 194	Physical Chemistry I (3)
Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Laboratory I (1)
Phys 13	General Physics (3)
Phys 14	General Physics Laboratory (1)
Geol 21	Principles of Geology (3)
elective	any course in the natural sciences or mathematics (3)

and one of the following:

Psyc 1	Introduction to Psychology (3)
Psyc 110	Experimental Design and Statistical Analysis (3)
Phil 128	Philosophy of Science (3)

Recommended B.S. Science Sequence

freshman year

Biol 21, 22	Principles of Biology and Laboratory (4)
Biol 28	Mendelian and Population Genetics (3)
Math 21, 22	Analytic Geometry and Calculus I and II (8) **or**
Math 41, 44	BMSS Calculus I and II (6)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)

sophomore year

Chem 51, 52, 55	Organic Chemistry and Laboratory (8)
Math 23	Analytic Geometry and Calculus III (4) **or**
Math 42, 43	BMSS Probability and Linear Algebra (6)
Biol 131 or Biol 132	Non-Vascular Plants (3) **or** Evolution of Vascular Plants (3)
Biol 133 or Biol 134	Invertebrate Zoology (3) **or** Comparative Vertebrate Anatomy (4)
elective	Psych 1, Introduction to Psychology (3) or Psych 110, Psychological Research and Statistics (3) or Phil 128, Philosophy of Sciences (3)

junior year

Geol 21	Principles of Geology (3)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Phys 13, 14	General Physics and Laboratory (4)
Biol 235	Microbiology (3)
Biol 211	Ecology (3)
Biol 220 or Biol 223	Cell Physiology (3) **or** Animal Physiology (3)
	elective (3)

senior year

Chem 31	Chemical Equilibria in Aqueous Systems (3)
Chem 187 or 194	Physical Chemistry I (3)
Biol 317	Evolution (3)
	Biol electives (6)
elective	natural sciences (3)

The B.S. in Molecular Biology

A specialized B.S. program enables students to focus on this distinctive and highly interdisciplinary field. The nature of the field requires extensive course work in chemistry, physics, mathematics and biology, and specialized laboratory and research experience. The molecular biology curriculum requires highly structured scheduling through three years of the program.

Requirements for the B.S. in Molecular Biology

College and university requirements (37 credit hours)

Engl 1	Composition and Literature (3)

Engl 2, 4, 6, 8 or 10	Composition and Literature: Fiction, Drama, Poetry (3)
A&S 1	Choices and Decisions (1)
Non-science electives	(30), to be broadly distributed in fields of thought other than natural sciences and mathematics, including at least 12 credit hours each in the humanities and social sciences.

Major Program

Mathematics (12 credit hours)

Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12)

Chemistry (19 credit hours)

Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Laboratory (1)
Chem 51, 52	Organic Chemistry (6)
Chem 55	Organic Chemistry Laboratory (2)
Chem 31, 194	Chemical Equilibria in Aqueous Systems and Physical Chemistry for Biological Sciences (6)

Physics (9 credit hours)

Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Laboratory I (1)
Phys 13	General Physics (3)
Phys 14	General Physics Laboratory (1)

Natural sciences, mathematics or computing science (6 credit hours)

electives	(6)

Molecular Biology (33 credit hours)

Biol 21	Principles of Biology (3)
Biol 28	Mendelian and Population Genetics (3)
Biol 220	Cell Physiology (3)
Biol 235	Microbiology (3)
Chem 371	Elements of Biochemistry I (3)
Chem 372	Elements of Biochemistry (3)
Biol 367	Molecular and Cellular Biophysics (3)
Biol 345	Molecular Genetics (3)

and 9 credit hours, including at least one course with laboratory † from the following:

Biol 391	Undergraduate Research (3) †
Biol 325	Topics in Genetics (3)
Biol 327	Cellular Regulation (3) †
Biol 339	Microbial Physiology (3)
Biol 343	Microbial Ecology (3) †
Biol 353	Virology (3)
Chem 377	Biochemistry Laboratory (3) †
Chem 378	Biochemical Preparations (1-3) †
ChE 341	Biotechnology I: Industrial Microbiology and Biochemistry (3)
ChE 342	Biotechnology II: Engineering Principles (3)

† designates laboratory courses within this category.

Recommended sequence for the B.S. in Molecular Biology

freshman year

Biol 21	Principles of Biology (3)
Biol 28	Mendelian and Population Genetics (3)
Math 21, 22	Analytic Geometry and Calculus I and II (8)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Phys 11, 12	Introductory Physics I and Laboratory (5)

sophomore year

Biol 220	Cell Physiology (3)
Biol 235	Microbiology (3)
Math 23	Analytic Geometry and Calculus III (4)
Chem 51	Organic Chemistry (3)
Chem 52, 55	Organic Chemistry and Laboratory (5)
Phys 13, 14	General Physics and Laboratory (4)

junior year

	Biol elective (3)
Biol 345	Molecular Genetics (3)
Chem 31	Chemical Equilibria in Aqueous Systems (3)
Chem 194	Physical Chemistry for Biological Sciences (3)
Chem 371, 372	Elements of Biochemistry I (6)

senior year

	electives (6)
Biol 367	Molecular and Cellular Biophysics (3)
Natural science	electives (6)

Special Programs. Students may apply for admission to an accelerated B.A.-doctor of medicine program and a B.A.-doctor of medical dentistry program. A six-year B.A.-M.D. program is offered in conjunction with the Medical College of Pennsylvania, and a seven-year B.A.-D.M.D. program is offered in conjunction with the University of Pennsylvania School of Dental Medicine. Students in these programs receive a B.A. from Lehigh and a graduate degree from the designated professional school within a six- or seven-year period. For details concerning admission to these programs, see Health Professions, Section III.

Departmental Honors. Any student may apply for admission through a potential thesis advisor. Students applying in their junior year are required to have a minimum cumulative average of 3.25 for the previous 4 semesters or a minimum of 3.5 for the previous 2 semesters. Students applying in their senior year are required to have a minimum average of 3.25 for the previous 4 semesters.

Requirements
A minimum of 12 hours of independent study (or undergraduate research and/or special topics courses) with grades of B or better is required. No more than 6 of these 12 hours may be offered to satisfy major program requirements. A 3.25 cumulative average must be maintained in the last 3 semesters. These courses should be pursued by the student as a comprehensive, sustained research effort the results of which are documented in the required honors thesis. This thesis must be unanimously approved by an examining committee composed of the advisory committee plus a professional biologist who is not a member of the department. The main content of the thesis must be presented at a public lecture.

Junior-Year Writing Certification

Beginning with the class of 1988, each student in the department must fulfill the junior-year writing certification for the College of Arts and Science. In the Biology Department students will be able to fulfill the requirement by taking a research course (Biol 225) with individual professors.

Minor in Biology

A minor in biology may be achieved by completing the following requirements:

Biol 21, 22	Principles of Biology and Laboratory (4)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Chem 51	Organic Chemistry (3)
Math 41	BMSS Calculus I (3)
	electives (12)
	total credits 27

Undergraduate Courses in Biology

1. Biology and Society (3)
Principles and implications of modern biological thought for nonscience, business, and engineering majors. Areas of high

social relevance, such as genetics, behavior, populations, and environment. May not be substituted for or taken in addition to Biol 21.

5. Humanistic Botany (3) spring
Introduction to the botanical world for non-majors in biology. Origins, evolution, taxonomy, horticulture, ecology, physiology and reproduction in plants. Two lectures, one laboratory.

21. Principles of Biology (3) fall-spring
Introduction to biology by study of selectd principles. Topics covered include cell structure and function, plant and amimal structure and function, diversity and evolution of organisms. Three lectures per week.

22. Introduction to Biology Laboratory (1) fall-spring
Laboratory observations and experiments to illustrate how biological information is acquired. Designed primarily as a laboratory to accompany Biol 21. Prerequisite: Biol 21 previously or concurrently. One three-hour laboratory per week.

28. Mendelian and Population Genetics (3) fall-spring
Mendel's Laws of Segregation and Independent Assortment, chromosome structure, mitosis, meiosis, linkages, gender determination, sex linkage, cytoplasmic inheritance, and gene frequencies in population. Laboratory emphasizes patterns of gene transfer in *Drosopila melanogaster*. Two lectures, one laboratory.

131. Non-Vascular Plants (3) fall
A comparative study of the ontogenetic and phylogenetic development of algae, fungi, and bryophytes. The life cycles and ecological importance of representative organisms are examined. Two lectures and one laboratory. Prerequisite: Biol 21.

132. Evolution of Vascular Plants (3) spring
A comparative study of the ontogenetic and phylogenetic development of vascular plants. The life cycles, ecological importance and cellular morphology of the higher plants are examined. Emphasis on the plants of Pennsylvania. Two lectures and one laboratory. Prerequisite: Biol 21.

133. Invertebrate Zoology (3) spring
Detailed survey of representative invertebrates. Anatomical and histological examination of selected types. Concepts of evolution and speciation. Two lectures and one laboratory. Prerequisites: Biol 21 and 22 or consent of department chairperson.

134. Comparative Vertebrate Anatomy (4) fall
A course in vertebrate zoology with emphasis on the study of homologous body structures in the various vertebrate classes and their relationship to the functional demands of habit and environment in each class. Detailed dissections of representative vertebrates are made in the laboratory. Two lectures and two laboratory periods. Prerequisites: Biol 21 and 22 or equivalent; sophomore standing.

151. Vertebrate Field Biolgy (3)
Field studies on the diversity and distribution of local vertebrates. Emphasis on methods of sampling, collecting and identifying populations and on measurement of the physical environment. Two lectures per week, laboratories on Friday afternoon and on Saturday during the first seven weeks. Prerequisites: Biol 21, 22 and consent of the department chairperson. Enrollment limited.

191. (Chem 193, Geol 191) Environmental Science Seminar (1)
Seminar on current problems and developments in environmental science. May be repeated for credit. Prerequisite: sophomore standing.

For Advanced Undergraduates and Graduate Students

211. Ecology (3) fall-spring
Basic principles and applications of ecological interrelationships. Examination of ecological phenomena at the individual, population, community, and ecosystem levels. Two lectures and one laboratory period or field trip. Prerequisite: at least one 100 level biology course or consent of department chairperson.

220. Cell Physiology (3) fall
The fundamental processes of life at the cellular level emphasizing the eukaryotes. Topics include aspects of thermodynamics and biochemistry, enzyme kinetics, membrane structure and function (including exchange phenomena, receptor systems, and electrical excitability), mechanisms of motility in muscle and cilia, energy transduction in chloroplasts and mitochondria, mechanisms and regulation of protein synthesis and cell growth. Two lectures and one laboratory. Prerequisites: Biol 21, 28 and Chem 52 and Phys 11 previously or concurrently.

223. Animal Physiology (3) spring
The functions and structures of vertebrate and invertebrate animals, with emphasis on adaptations to marine, freshwater, and terrestrial environments. Topics include respiration, circulation, energy allocation, locomotion, osmoregulation, excretion, information acquisition via sensory organs, and coordination through nervous and endocrine systems. Two lectures, one laboratory. Prerequisite: Biol 133 or 134.

225. Introduction to Biological Research (3)
Laboratory or field research project and literature survey presented as research papers. Restricted to and required of majors in biology and molecular biology during the junior year.

231. Natural History and Ecology (3) summer
A concentrated course in recognition of species of plants and animals and study of their interrelationships in natural and altered environments. Lectures and seminars in use of keys and preservation of collections. Designed for secondary school teachers in life sciences. Prerequisite: graduate standing or consent of the department chairperson.

232. Natural History and Ecology Workshop (3)
Field and laboratory work in natural history and ecology. Must be taken concrrently with Biol 231.

235. Microbiology (3) spring-fall
The appearance, physiology and taxonomy of prokaryotes. Two lectures and one laboratory period. Prerequisite: Chem 52, previously or concurrently.

241. Ecology of the Wetlands (6) summer
Study of plants and animals of wetlands areas and their interrelationships with the environment. The importanace of the wetlands to the marine environment and methods of conservation. Independent study will form part of the course. Primarily designed for secondary school teachers of the sciences. Prerequisite: consent of the department chairperson. (Offered only at The Wetlands Institute.)

251. Frontiers of Biology (1) fall, spring
Special seminars, discussions and library research in curriculum development projects focusing on and correlated with the current theme of the LVAIC Frontiers in Biology seminar series. May be repeated for credit. Late afternoon and evening sessions at each of the three LVAIC campuses. Prerequisite: consent of the department chairperson.

256. Human Genetics and Reproduction (3)
Processes and mechanisms of human heredity. Emphasis at the cellular and molecular levels. Analysis, organization, expression and evolution of human genome. Genetic aspects of

reproduction and development, mapping human chromosomes, cell hybridization, molecular analysis of gene structure and function, behavior and intelligence, primate origins and evolution, immunogenetics, cancer and oncogenes, genetic technologies. Prerequisite: Biol 28.

261. Special Topics in Biology (1-3)
Research, conferences and reports on selected topics not covered in the general undergraduate offerings. May be taken more than once for credit. Prerequisite: consent of the department chairperson.

262. Special Topics in Biology (1-3)
Continuation of Biol 261.

309. Aquatic Biology (3) alternate years
Physical, chemical and biological aspects of fresh-water environment, including cyclic and seasonal changes. Major groups of organisms and their interactions. Two lectures and one laboratory or field trip. Prerequisite: Biol 21 or consent of the department chairperson.

311. Water Pollution Biology (3) fall, alternate years
Water pollution issues and fundmental principles of aquatic ecology, field trips to impacted lakes and streams in Pennsylvania. Stripmining, stream siltation, acid mine damage, eutrophication, acid rainfall, and other topics. Prerequisite: Biol 211 or consent of department chairperson.

313. General Histology (3) fall-spring
The techniques of preservation and preparation of animal and plant tissues for microscopical study; comparative studies of fresh and preserved tissues. One lecture and two laboratory periods. Prerequisite: Biol 134 or consent of the department chairperson.

314. Developmental Biology (3) spring
Germ cell formation, fertilization, early development and the origin of the principal organ systems of vertebrates. Molecular basis of developmental processes, particularly the location, structure and regulation of information in developing animals. Two lectures and one laboratory per week. Prerequisite: Biol. 133 or 134 and 220 or 223.

315. Terrestrial Ecology (3) fall
Structural and functional aspects of terrestrial communities. Ecosystem analysis to evaluate flux of carbon and energy through various biomes. Two lectures, one laboratory or field trip. Prerequisite: Biol 211 or consent of the department chairperson.

317. (Geol 317) Evolution (3) spring
Mechanisms of evolution, emphasizing genetic structure and variation of populations, and isolation. Origin of species and higher taxa. Rates of evolution, extinction. Prerequisites: Biol 28 and any two 100 level biology courses.

319. Reproduction and Mating Systems (3)
Patterns of reproduction and sexuality in plants and animals with emphasis on natural selection and ecological principles. Topics include hermaphroditism, neoteny, larvel forms, parental investment, complex life cycles population structure. Lectures, discussions, readings from textbook, student reports. Prerequisites: Biol 28; Biol 211 or 317.

325. Topics in Genetics (3)
Lectures and student projects on selected aspects of genetics: the genetics and evolution of particular organisms, regulation of gene transmission, behavior genetics, human evolution and genetics. Prerequisite: Biol 345 or consent of department chairperson.

327. Cellular Regulation (3)
Systems of regulation of cellular activity and multicellular coordination; cell replication, movements and integration of activity within and between cells. Two lectures, one laboratory. Prerequisite: Biol 220.

329. Herpetology (3)
Biology of amphibians and reptiles. Two lectures, one laboratory or field trip per week. Prerequisite: Biol 134.

333. Symbiosis (3) fall
Consideration of factors governing symbiotic relationships, including phoresis, commensalism, parasitism, mutualism. Lectures and demonstrations emphasizing the theoretical and applied aspects of morphological and physiological adaptation, nutrient assimilation and metabolism, development, host reactions, and the dynamics of host-symbiont interactions are presented. Laboratory experiments are designed to acquaint the student with techniques, evaluation of data, and to demonstrate principles. Two lectures, one laboratory. Prerequisite: Biol 21.

335. (Psyc 335) Animal Behavior (3) spring
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral stimuli, and adaptive value of specific behavior patterns. Prerequisite: Biol 21 or consent of the department chairperson.

336. Animal Behavior Laboratory (2)
Experiments and field observations illustrating principles discussed in Biol 335. Emphasis on observing animals, performing experiments, collecting and analyzing data, and individual research. Six hours of laboratory per week. Corequisite: Biol 335 or 337. Limited enrollment.

337. (Psyc 337) Sociobiology (3)
Social systems of vertebrate and invertebrate groups. Emphasis on ecological and evolutionary factors that influence social behavior. Prerequisite: Biol 21 or consent of department chairperson.

338. Endocrinology/Reproductive Physiology (3)
Lectures and discussions designed to provide a broad background in mammalian endocrinology and reproductive physiology from the molecular to the organismic level. Emphasis will be placed on hormone and drug receptor mechanisms and biochemical basis of hormone and related drug actions. Prerequisites: Biol. 220 or 223, and Chem. 371.

339. Microbial Physiology (3) spring
Physiology of bacteria, yeast and fungi. Antibiotics: their biosynthesis and effect on microbial cell structure and function. Prerequisites: Biol 235 and either Biol 220 or Chem 371 and 372.

341. Biology of Marine Animals (6) summer
Emphasis on comparative morphology and physiology of marine animals. Field trips for ecological observation and collection as well as anatomical study and physiological experimentation. Prerequisites: consent of the department chairperson and two semesters of biology. (Offered only at The Wetlands Institute.)

343. Microbial Ecology (3)
Qualitative and quantitative study of bacteria and the physical and chemical features of their environments. Simulation of natural habitats in the laboratory to illustrate growth, competition, and sucession of organisms. Prerequisite: Biol 235 or equivalent course.

345. Molecular Genetics (3)
The organization and replication of genetic material; mutagenesis; mechanisms of regulation; mechanisms of gene transmission involving prokaryotes and unicellular eukaryotes and their viruses; techniques for intervention into genetic organization and expression. Two lectures and one laboratory. Prerequisites: Biol 28, 220 and 235 or consent of the department chairperson.

353. Virology (3) spring
Structure and replication of viruses, including those infecting bacteria, plants and animals. Emphasis will be on the organization, replication and regulation of expression of viral

geonomes and on the mechanisms of virus assembly and release. Special attention will be given to human pathogenic viruses. Prerequisite: Biol. 220, 235, and Chem. 371.

361. Sanitary Microbiology (3) spring
Laboratory, field work, and reports on the microbiology of water supplies, waste disposal, and food processing. Two lectures, one laboratory. Prerequisite: one semester of microbiology.

367. Molecular and Cellular Biophysics (3)
Physico-chemical aspects of modern molecular and cellular biology, with emphasis on the structure and dynamics of nucleic acid complexes and membranous intracellular organelles. A study of the physicalbasis of techniques for biomolecular purification and analysis. Prerequisite: Biol. 220, 235, and Chem. 371.

371. (Chem 371) Elements of Biochemistry I (3) fall
A general study of carbohydrates, proteins, lipids, nucleic acids and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year or organic chemistry.

372. (Chem 372) Elements of Biochemistry II (3) spring
Dynamic aspects of biochemistry; enzyme reactions including energetics, kinetics and mechanisms; metabolism of carbohydrates, lipids, proteins and nucleic acids; photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chem 371.

375. (Psyc 375) Neuroanatomy of Behavior (3) fall
Neuroanatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology. Prerequisite: Psych 177 or Biol 220 or 223 or 335.

376. (Psyc 382) Endocrinology of Behavior (3) spring
Hormonal effects upon animal and human behavior. Emphasis on neuroendrocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: Psych 178 or Biol 220 or 223 or 335.

391. Undergraduate Research (3)
Laboratory and/or field research under tutorial with a faculty member. May be taken more than once for credit. Prerequisites: junior standing and at least 5 completed courses in biology, including Biol 225, a cumulative average of 3.0 in the major, and consent of chairperson.

Mini-Courses at The Wetlands Institute

The following courses, Biol 381 through 386, are one-credit mini-courses offered only at The Wetlands Institute. Approval of the department chairperson is required for all courses.

381. Phytoplankton of Estuaries (1)
Survey of the phytoplankton found in New Jersey salt marsh waters. Laboratory work in collecting and identifying organisms and lectures on the morphology, biochemistry, and physiology of the organisms.

382. Plant Succession in Salt Marshes (1)
Survey of the large plants found in salt marshes and in other marine environments. Field work collecting and identifying the plants; lectures on their biochemistry, physiology and morphology.

383. Marine Invertebrate Zoology (1)
The dominant taxa of the marine environment; the wetlands fauna, including taxonomy, life history, adaptations and interrelationships of these organisms. Consideration of the environmental parameters determining the distribution and abundance of marine fauna.

384. Estuarine Zooplankton (1)
Study of temporary and permanent members of the animal plankton of shallow water. Sampling techniques, life histories and morphology of major forms. Lectures, laboratories and field trips.

385. Marine Habitats (1)
Ecological field course in the planktonic, benthic, marsh and sand beach habitat of the coast of southern New Jersey. Emphasis on the major biotic associations in each area and their relationship to physical and chemical influences in the environment. Competition and predation in each habitat.

386. Marine Fish Taxonomy (1)
Lectures in anatomy and physiology of marine fishes. Laboratory will emphasize collecting procedures and identification of specimens.

Graduate Study in Biology

The Biology Department accepts a limited number of students who are interested in graduate study towards the master of science or doctor of philosophy degrees. The department averages about twenty full-time graduate students in residence.

The program initially emphasizes breadth in biology followed by concentration in a special field of interest. Students entering the program with a bachelor's degree must complete the M.S. degree, including submission of an acceptable master's thesis, before proceeding to the Ph.D. program. Because of the small number of department staff members and the restricted number of graduate students, staff and students work together closely, especially during the years of student specialization.

Departmental research thrusts are focusted in two general areas; environmental/organismal and cellular/molecular biology. Environmental/organismal research includes: functional morphology of feeding in reptiles; organismal energetics; aquatic toxicology, including fate and effect of atmospheric pollutants; marine and freshwater zooplankton ecology; dynamics of aquatic food chains; predator-prey interactions; sociobiology of coral reef and freshwater fishes. Cellular/molecular biology include: behavior of motile cells; chemostat studies of microbial evolution; biochemistry and genetics of microorganisms oriented to biotechnology; plant cytochemistry; developmental molecular genetics.

Each entering student is initially guided by his or her own faculty committee. A separate M.S. or Ph.D. committee later directs progress towards the advanced degree and tailors the program to fit special needs and interests of the student. Within the Ph.D. program there are three formal examinations, the qualifying exam, the general exam, and the dissertation defense.

The prerequisite for graduate work in biology is undergraduate training in biology, chemistry, physics, and mathematics approximately equivalent to that taken by biology majors at Lehigh University. Minor deficiencies in these areas may be completed during the first year of graduate study—usually, however, without graduate credit. Candidates for admission to graduate study in biology must take the Graduate Record Examination Advanced test in biology as well as the GRE Verbal and Quantitative tests. Failure to include results of these examinations with the application for admission can seriously delay or prevent action on the application.

Graduate Courses in Biology

402. Comparative Animal Physiology (3)
Lectures and seminars on selected areas in the comparative physiology of animals. Introduction to the current literature of subjects studied. These include mechanisms of osmotic control, temperature effects, nerve and muscle physiology and others. Prerequisite: Biol 220 or 223.

405. Special Topics in Biology (microbiology) (3)
Research, conferences, and reports on selected topics not covered in the general graduate offerings. May be taken more than once for credit.

406. Biological Seminar (1)
An advanced seminar in current developments including departmental research. Required for candidates for graduate degrees. May be taken more than once for credit.

407. Biological Research (1-9)
Investigations in any phase of the biological sciences according to the student's preparation and interests.

409. Advanced Morphology (3)
A laboratory course in special phases of morphology, such as comparative osteology, comparative morphology or embryology of the vertebrates, etc., to meet the individual interests of the student.

411. Advances in Water Pollution Biology (3)
Discussion of major water pollution problems will be linked to laboratory experiments and field investigations in local streams and lakes. An independent research project is required. Two lectures and one laboratory or field trip. Not open to students who have received credit for Biol 311.

414. Advanced Ecology (3)
Seminars, conferences and directed field work with emphasis on theoretical models and their application to real biological systems. May be taken more than once for credit. Prerequisite: consent of the department chairperson.

415. Cytochemistry (3)
A study of morphological and biochemical events during cell growth and differentiation including lectures, laboratories, and student reports on current literature. Special emphasis is placed on developmental patterns and laboratory procedures of the cytochemist. Prerequisite: consent of the department chairperson.

417. Marine Ecology (3)
Advanced study of the physical and chemical influences in the marine environment on organisms and their interrelations. Ecological theory groups, productivity, interrelationships of plants and animals and the role of microorganisms in the sea. Prerequisite: consent of the department chairperson.

418. Biological Oceanography (3)
Surveys of marine plant and animal plankton; nekton and benthos. Composition of vrious groups, productivity, interrelationships of plants and animals and the role of microorganisms in the sea. Prerequisite: consent of the department chairperson.

419. Analysis of Reproduction and Mating Systems (3)
Study of reproduction and sexuality in plants and animals with emphasis on current hypotheses as reported in the literature. Topics include hermaphroditism, neoteny, larval forms, parental investment, complex life cycles, population structure. Lecture sections may be in common with Biol 319. Readings from primary source material and review articles. One review paper and one research proposal are required, and together with readings forms the basis for discussion sections and examinations. Prerequisite: consent of the department chairperson. Not open to students who have taken Biol 319.

424. Community Ecology (3)
Current concepts in the ecology of animal communities. Theoretical and experimental approaches to understanding the primary factors which regulate the structure and dynamics of communities. Focus on biotic interactions (competition and predation). Prerequisite: Biol 211 or equivalent.

429. Advances in Herpetology (3)
Lectures and readings from the primary literature on current reserch in amphibian and reptilian biology. Two lectures, one discussion session and one laboratory or fiels trip. In addition, a week-long field trip during spring vaction is required. Not open to students who have received credit for Biol 329.

433. Growth and Development in Plants (3)
A comparative study of embryo and cellular development in the plant kingdom including the algae, bryophytes and tracheophytes. Emphasis is placed on morphology, physiology and the role of macromolecular substances during growth and differentiation. Literature search, experimental work and oral reports. Two lectures and one laboratory.

437. Advanced Sociobiology (3)
Critical evaluation of the theoretical foundation in sociobiology. Emphasis placed on kinship, altruism, mate choice, parental investment, parent-offspring conflict, etc. Lectures and seminars. Not open to students who have taken Biol 337.

441. Marine Botany (3)
A study of the morphological, physiological, biochemical and ecological features of those plants found primarily in the salt water environment. Emphasis is placed on the evolutionary and ecological significance of the phytioplankton, benthic algae and rooted aquatic plant divisions associated in and near the oceans. The economic importance of these plants is considered. Laboratory work, field work and library searches and reports.

442. Marine Zooplankton (3)
A comprehensive study of neritic and oceanic plankton. Studies on the life history, morphology and distribution of both holoplanktonic and meroplanktonic animals. Prerequisite: consent of the department chairperson.

443. Ichthyology (3)
Lectures and laboratory on the anatomy, physiology, behavior and taxonomy of marine and fresh-water fishes.

444. (Geol 444) Multivariate Analysis (3)
The strategy of the application of multivariate analysis techniques to problems in geology and biology. Analysis of large data matrices by factor analysis, cluster analysis, discriminant function analysis, ordination, and related techniques. Examples from both geology and biology. Prerequisites: Geol 10 and Geol 321 or approved equivalents.

461. Molecular Cell Biology I (3)
An advanced course covering the molecular structures and mechanisms involved in cell physiology, including genome structure and replication, RNA synthesis/processing, protein synthesis and transport, biomembranes, and determination of cell structure.

462. Molecular Cell Biology II (3)
A continuation of Biol 421, with emphasis on developmental cell biology, molecular aspects of reproduction and disease, and biotechnology.

463. Biomolecular Laboratory Techniques (3)
A laboratory course on up-to-date techniques for the analysis of nucleic acids and proteins.

464. Ultrastructure Laboratory Techniques (3)
A lecture-laboratory course on modern capabilities for ultra-high resolution structural analysis of biological systems.

465. Topics in Molecular Biology (1-3)
Advanced seminar in areas of molecular biology; may be repeated when a different topic is offered.

466. Topics in Cell and Developmental Biology (1-3)
Advanced seminar in areas of cellular and developmental biology; may be repeated when a different topic is offered.

480. (Geol 480) Marine Science Seminar (1)
An advanced interdisciplinary seminar on various problems of marine sciences, with visting speakers and student presentations. May be substituted for Biol 406.

Chemical Engineering

Professors. John C. Chen, Ph.D. (Michigan), *chairman* and Carl R. Anderson professor; Fred P. Stein, Ph.D. (Michigan), *associate chairman;* Philip A. Blythe, Ph.D. (Manchester, England); Hugo S. Caram, Ph.D. (Minnesota); Marvin Charles, Ph.D. (Brooklyn Polytechnic); Curtis W. Clump, Ph.D. (Carnegie-Mellon); Mohamed S. El-Aasser, Ph.D. (McGill); Arthur E. Humphrey, Ph.D. (Columbia), T. L. Diamond Professor of Biotechnology; William L. Luyben, Ph.D. (Delaware); Matthew J. Reilly, Ph.D. (Illinois); Eric P. Salathe, Ph.D. (Brown); William E. Schiesser, Ph.D. (Princeton), McCann Professor; Leslie H. Sperling, Ph.D. (Duke); Leonard A. Wenzel, Ph.D. (Michigan).
Associate professors. Christos Georgakis, Ph.D. (Minnesota); James T. Hsu, Ph.D. (Northwestern); Andrew Klein, Ph.D. (North Carolina State); Janice A. Phillips, Ph.D. (Pennsylvania); Cesar A. Silebi, Ph.D. (Lehigh).
Assistant professor. Harvey G. Stenger, Jr., Ph.D. (M.I.T.).
Adjunct professors. Jacob M. Geist, Ph.D. (Michigan); William R. Hencke, M.S.E. in ChE (Michigan).
Adjunct associate professors. Montford S. Benson, Ph.D. (Missouri). Paul M. Mathias, Ph.D. (Florida).
Research engineers. E. Sudol, Ph.D. (Lehigh); Kemel Tuzla, Ph.D. (Technical University of Istanbul).
Research scientists. Victoria Dimonie, Ph.D. (Polytecnic Institute, Romania); Malcolm Chainey, Ph.D. (Kent Polytechnic, England).

Chemical engineers serve a wide variety of technical and managerial functions within the chemical processing industry. For a lifetime of effectiveness they need a sound background in the fundamental sciences of chemistry and physics, a working capability with mathematics, numerical methods, and application of computer solutions, and a broad education in humanities, social sciences, and managerial techniques.

These bases are applied in a sequence of courses called chemical engineering in which logic and mathematical manipulation are applied to simulated chemical processing problems.

With the resulting habits of precise thought coupled to a broad base in scientific and general education, Lehigh graduates have been effective throughout industry and in advanced professional education. No effort is made in orientation toward any specific industry, but adaptation is rapid and the fundamental understanding forms the base for an expanding career.

The program is also designed to prepare a student for graduate study in chemical engineering. Further study at the graduate level leading to advanced degrees is highly desirable if an individual wishes to participate in the technical development of the field. The increasing complexity of modern manufacturing methods requires superior education for men and women working in research, development, and the design fields or for teaching.

Physical facilites. The department is located in Whitaker Laboratory where 40,000 square feet of space are available for departmental research, teaching, and offices.

The building includes facilities designed for digital computation, calibration standards, minicomputers for process dynamics study, reaction kinetics and thermodynamics research with special protection for high-pressure research, special equipment for biochemical engineering, and a wide range of general laboratory equipment for undergraduate study of the behavior of typical chemical processing units.

Career Opportunities

Chemical engineers play important roles in all activities bearing on the chemical process industry. These include the functions of research, development, design, plant construction, plant operation and management, corporate planning, technical sales, and market analysis.

The industries that produce chemical and/or certain physical changes in fluids, including petroleum and petrochemicals, rubbers and polymers, pharmaceuticals, metals, industrial and fine chemicals, foods, and industrial gases, have found chemical engineers to be vital to their success. Chemical engineers are also important participants in pollution abatement, energy resources, and national defense programs.

Special Programs and Opportunities

The department operates a cooperative program that is optional for specially selected students who have completed their sophomore year. This program affords early exposure to industry and an opportunity to integrate an academic background with significant periods of engineering practice. Students in this program are able to earn most of their college expenses.

Opportunities for undergraduate involvement in research projects, design projects, and programs of independent study are many, but are usually arranged specifically between a student and a professor. The curricular flexibility encourages the student to emphasize an area of special interest in the selection of electives. In some cases these electives lead to a minor in addition to the chemical engineering major.

Requirements of the Major

freshman year: see Recommended Freshman Year, page 36.

sophomore year, first semester (18 credit hours)

ChE 43	Introduction to Chemical Engineering (4)
Chem 31	Chemical Equilibria in Aqueous Systems (3)
Math 23	Analytic Geometry and Calculus III (4)
Eco 1	Economics (4)
	elective (3)

sophomore year, second semester (18 credit hours)

ChE 44	Chemical Process Analysis I (4)
Math 205	Linear Methods (3)
Chem 187	Physical Chemistry I (3)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
	elective (3)

junior year, first semester (16 credit hours)

ChE 141	Chemical Process Analysis II (4)
Chem 51	Organic Chemistry (3)
Chem 53	Organic Chemistry Laboratory (1)
Chem 189	Physical Chemistry II (3)
Chem 192	Physical Chemistry Laboratory (2)
	elective (3)

junior year, second semester (17 credit hours)

ChE 142	Chemical Process Analysis III (4)
ChE 202	Chemical Engineering Laboratory I (3)
ChE 210	Chemical Engineering Thermodynamics (4)
Chem 52	Organic Chemistry (3)
	elective (3)

junior year, summer

ChE 100	Summer Employment

senior year, first semester (17 credit hours)

ChE 203	Chemical Engineering Laboratory II (2)
ChE 211	Chemical Reactor Design (3)
ChE 233	Process/Plant Design (3)
	electives (9)

senior year, second semester (18 credit hours)

	ECE 81 (4)
	Ch.E elective (3)
	electives (11)

The total number of credits required for graduation is 134.

A total of 42 credits in electives must be taken. These electives are of six types:

(a) General Studies: A total of 15 hours of electives in humanities and social science. (Note that these electives are in addition to the 10 hours of required General Studies.

(b) Courses in Other Engineering Departments (CE, ECE, IE, MEM, MAT): A total of 8 credit hours is required.

(c) Chemistry: 3 credit hours of 200-level or higher.

(d) Science: 3 credit hours in any course in chemistry, mathematics, physics, biology or geology.

(e) Chemical Engineering: 3 credit hours. All students who progress through the program in the usual eight semesters must take this elective in their eighth semester. Cross listed courses used for other electives or requirements are not acceptable. Only 300-level or 400-level courses or Ch.E. 185 or 186 are accepted.

(f) Free electives: 6 credit hours in any subject area (including advanced chemical engineering) are required.

Undergraduate Courses

43. Introduction to Chemical Engineering (4) fall
Material and energy balances with and without chemical reaction. Applications in chemical process calculations and in design of separations cascades, especially distillation. Plant trips and special lectures introductory to the profession.

44. Chemical Process Analysis I (4) spring
Fluid mechanics and its applications to chemical processes. Momentum and energy balances in fluid flow. Dimensional analysis. Fluid flow in pipes, packed and fluidized beds. Mixing and agitation. Filtration and sedimentation. Three lectures and one calculation period per week.

60. Unit Operations Survey (3) fall
The theory of heat, mass and momentum transport. Laminar and turbulent flow of real fluids. Heat transfer by conduction, convection, and radiation. Application to a wide range of operations in the chemical and metallurgical process industries.

141. Chemical Process Analysis II (4) fall
Fundamental principles of heat and mass transfer. Application of these transport fundamentals and conservation laws to the analysis and design of chemical processing units involving heat and/or mass transfer. Prerequisite: ChE 43 and ChE 44.

142. Chemical Process Analysis III (4) spring
Review of the physical and chemical laws that are the basis for the mathematical modeling of dynamic chemical engineering systems. Digital computer solution techniques for mathematical models expressed as systems of algebraic, ordinary and partial differential equations. Introduction to process control equipment and stability analysis. Review of Laplace Transforms, transfer functions, block diagrams and linearization. Prerequisite: ChE 141 and Math 205.

179. Professional Development (1) fall
Elements of professional growth, registration, ethics, and the responsibilities of engineers both as employees and as independent practitioners. Proprietary information and its handling. Patents and their importance. Discussions with the staff and with visiting lecturers. A few plant trips. Prerequisite: junior standing.

185. Undergraduate Research I (3)
Independent study of a problem involving laboratory investigation, design, or theoretical studies under the guidance of a senior faculty member.

186. Undergraduate Research II (3)
A continuation of the project begun under ChE 185. Prerequisite: ChE 185 or consent of the department chairperson.

For Advanced Undergraduates and Graduate Students

202. Chemical Engineering Laboratory I (3) spring
The laboratory study of chemical engineering unit operations and the reporting of technical results. One three-hour laboratory and one lecture period per week. Independent study and both group and individual reporting. Prerequisite: ChE 141.

203. Chemical Engineering Laboratory II (2) fall
Laboratory experience with more complex chemical processing situations including processes involving chemical reactions and those controlled automatically. Prerequisites: ChE 202 and ChE 142.

207. (Math 207) Introduction to Biomedical Engineering and Mathematical Physiology (3) fall
Topics in human physiology and mathematical analysis of physiological phenomena, including the cardiovascular and respiratory systems, biomechanics, and renal physiology; broad survey of bioengineering. Independent study projects. Prerequisite: Math 205.

210. Chemical Engineering Thermodynamics (4) spring
Energy relations and their application to chemical engineering. Consideration of flow and nonflow processes. Evaluation of the effects of temperature and pressure on the thermodynamic properties of fluids. Heat effects accompanying phase changes and chemical reactions. Determination of chemical and physical equilibrium. Prerequisite: Chem 187 or equivalent.

211. Chemical Reactor Design (3) fall
The application of chemical kinetics to the design and operation of chemical reactors. Plug flow and continuous stirred tank reactors. Homogeneous and heterogeneous reaction kinetics. Design of isothermal and adiabatic reactors. Prerequisite: ChE 141, ChE 210 or equivalent.

233. Process/Plant Design (3) fall
Economic principles involved in the selection of process alternates and determination of process operation costs. Preliminary design of chemical plants including optimization of process configuration, market limitations on plant planning, environmental and regulatory restrictions. Prerequisite: ChE 141 and ChE 210.

301. Process Design (3) spring
Study of the strategy of chemical process design with emphasis on optimum order of steps, flow diagrams, energy balances, recycle ratios and their effect on the economics of the operation. Survey of methods for ordering equations. Discussion of process optimization for nonlinear systems. Effects of uncertainty in process design.

312. (Chem 312, Mat 312) Fundamentals of Corrosion (3) fall
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and passivity. Nonelectrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisite: Met 210, Chem 187, or equivalent. Leidheiser or Smyth

320. Waste Water Control (3)
The physical processes of importance in the design of industrial waste-water treatment facilities. Topics will include sedimentation and filtration processes as well as advanced methods such as adsorption, ion exchange, osmosis, foaming, freezing, and hydrate formation.

321. Fundamentals of Air Pollution (3)
Introduction to the problems of air pollution including such topics as: sources and dispersion of pollutants; sampling and analysis; technology of economics and control processes; legislation and standards. Prerequisite: senior standing in the College of Engineering and Applied Sciences.

331. Distillation (3) spring, every other year
Design and operating strategies and techniques. Computer solutions for simple and complex multicomponent distillation columns. Shortcut design methods. Tray hydraulics and constraints. Petroleum fractionators and azcotropic and extractive distillation.

335. (Mat 335) Principles of Semiconductor Materials Processing (3) fall
Description and analysis of the processing steps involved in microelectronic material fabrication. Emphasis will be placed on the chemistry of the fabrication steps, mathematical modeling of the transport and chemical reaction phenomena, and interpretation of experimental methods and data. Prerequisites: a course in thermodynamics, and senior standing.

341. Biotechnology I: Industrial Microbiology and Biochemistry (3) fall
The microbiology of industrially important microorganisms and of waste-water treatment processes. Microbial and enzyme kinetics. Selection, screening, development, and maintenance of industrial microrganisms. Formulation of industrial fermentation media. Biochemical and physico-chemical principles of recovery and purification processes. Industrial aspects of recombinant DNA technology.

342. Biotechnology II: Engineering Principles (3) spring
Engineering principles of bio-processing. Fundamentals of heat and mass transfer, mixing, and biocatalysis applied to the design of fermentors; other bioreactors; recovery and purification processes. Sources of raw materials for and formulation of media for industrial bioconversions. Principles of sterilization and design for aseptic operation. Design of biological waste-water treatment processes. Economics of bio-processing. Special topics (e.g. mixed cultures, cell-plant culture) as time permits.

350. Special Topics (1-3)
A study of areas in chemical engineering not covered in courses presently listed in the catalog. May be repeated for credit if different material is presented.

360. (ME 360) Nuclear Reactor Engineering (3)
A consideration of the engineering problems in nuclear reactor design and operation. Topics include reactor fuels and materials, thermal aspects, instrumentation and control problems, radiation protection and shielding, fuel processing, and reactor design. Prerequisite: senior standing in the College of Engineering and Applied Sciences.

380. Design Projects (1-6) fall-spring
Design project work as a member of a team preferably including students from different disciplines. The project attacks a problem which, when possible, involves one of the local communities or industries. Specific projects are normally guided by faculty from several departments with consultants from off the campus. The course may be repeated for credit.

386. Process Control (3) fall
Laplace transformation and transfer functions, frequency response, feedback, and feedforward control. Open loop and closed-loop stability analysis using root locus and nyquist techniques, design of feedback controllers with time and frequency domain specifications. Experimental process identification, introduction to sampled-data control theory. Prerequisite: ChE 142 or equivalent.

387. (ECE 387, ME 387) Digital Control (3) spring
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability state feedback control. (2 lectures and one laboratory per week) Prerequisite: Ch.E. 386 or E.C.E. 212 or M.E. 342 or consent of instructor.

388. (Chem 388) Polymer Synthesis and Characterization Laboratory (3) spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: Chem 51, 187 or 191.

392. (Chem 392) Polymer Science (3) spring
Introduction to concepts of polymer science. Kinetics and mechanism of polymerization, synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: Chem 187 or equivalent.

393. (Chem 393, Mat 343) Physical Polymer Science (3) fall
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline, and paracrystalline states (including viscoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology, and behavior. Prerequisite: one year of physical chemistry.

394. (Chem 394) Organic Polymer Science (3) spring
Organic chemistry of synthetic high polymers. Functionality and reactivity of monomers and polymers. Theory of stepgrowth and chaingrowth polymerization in homogeneous and heterogeneous media. Polymerization by addition, elimination, substitution and coupling reactions. Ionic free-radical and coordinate catalysis. Prerequisite: one year of physical chemistry and one year of organic chemistry.

Graduate Programs

The department of chemical engineering offers graduate programs leading to the master of science, master of engineering, and doctor of philosophy degrees. The programs are all custom tailored for individual student needs and professional goals. These individual programs are made possible by a diversity of faculty interests that are broadened and reinforced by cooperation between the department and several research centers on the campus.

A free flow of personnel and ideas between the centers and academic departments insures that the student will have the widest choice of research activities. The student is also exposed to a wide range of ideas and information through courses and seminars to which both faculty and center personnel contribute. In addition, strong relationships with industry are maintained by the department and the research centers, some of which operate industrially sponsored liaison programs whereby fundamental nonproprietary research is performed in areas of specific interest to participating sponsors.

While the department has interacted with most of the centers on campus, it has had unusually strong and continuing liaisons with Emulsion Polymers Institute, Process Modeling and Control Research Center, Institute for Thermo Fluid Engineering and Science, Materials Research Center, Center for Surface and Coatings Research, and the Biotechnology Research Center.

In addition to interacting with the centers, the department originates and encourages programs that range from those that are classical chemical engineering to those that are distinctly interdisciplinary. The department offers active and growing programs in: emulsion polymerization and latex technology; bulk polymer systems; process control; process improvement studies; rheology; computer applications; environmental engineering; thermodynamics; kinetics and catalysis; enzyme technology; and biochemical engineering.

Career Opportunities

Master of science and doctor of philosophy graduates in the chemical engineering area are sought by industry for activities in the more technical aspects of their operations, especially design, process and product development, and research. Many of these graduates also find opportunities in research or project work in government agencies and in university teaching and research.

Physical Facilities

The department is well equipped for research in polymer science and engineering, catalysis and reaction kinetics, thermodynamic property studies, fluid dynamics, heat and mass transfer, process dynamics and control, and enzyme engineering and biochemical engineering.

The Departmental and University computing facilities, including microcomputers, computer interfaces, and mainframes, are used for research purposes themselves or in support of the experimental facilities.

In addition, the Chemical Process Modeling and Control Research Center operates a CYBER 810 computer system with several high and ultra high resolution terminals ideally suited for graphical representations.

Special Programs

Master of engineering design option. For those interested in design, the department offers the master of engineering design option. In this program, the student works on a design project proposed by the process design group of a cooperating industry. Direction of the design project is shared by the cooperating industry and a member of the faculty. Students desiring to enroll in this program should indicate that fact at the time they apply for admission.

Polymer science and engineering. The polymers activity includes work done in the Materials Research Center, the Center for Surface and Coatings Research, the Emulsion Polymers Institute, the department of chemistry, and the department of chemical engineering.

About a dozen faculty members from these organizations or areas have major interests in polymers and cooperate on a wide range of research projects. For students with deep interest in the area, degree programs are available leading to the master of science and doctor of philosophy degrees in polymer science and engineering.

Research activities in which chemical engineering students and faculty are involved include a major study of impregnation of bridge decks with polymers to increase surface life; studies of the mechanism of kinetics of emulsion polymerization and copolymerization, colloidal surface and interfacial aspects of emulsion polymers, and the process involved in their preparation, with special attention to the relationship between process parameters and properties of polymers; work on polymer blends, especially interpenetrating networks, and the application of these materials to sound-deadening; rheology of viscoelastic materials; crystallization behavior from polymer melts and solutions; polymer film characteristics and the tailoring of these properties for selective transfer rates; latex film drying rates; coatings and the hiding capabilities of micropores; and the preparation of polymeric materials from agricultural raw materials.

Master of engineering degree. Students may earn the master of engineering degree in chemical engineering upon completion of a course of study and an engineering project meeting all the requirements of the master of science degree. The master of engineering student, however, elects courses closer to engineering practice, and carries out a project of more practical engineering flavor than that of the M.S. candidate. In some cases the project of the master of engineering student will be done in close collaboration with local industry, as noted above.

Major Requirements

The requirements for the master of science degree are listed in the section on The Graduate School. All candidates for the M.S. degree are required to complete a master of science research report for which three to six hours of graduate credit are earned. Course selection is done individually for each student, although ChE 400 and ChE 415 are required courses.

The requirements for the doctor of philosophy degree also are listed in the section on The Graduate School. In addition to an approved course and thesis program, the Ph.D. student is expected to pass a qualification examination given within the first year of doctoral-level study and to pass a general examination based on a research problem presented by the student.

Advanced Courses in Chemical Engineering

400. Chemical Engineering Thermodynamics (3) fall
Applications of thermodynamics in chemical engineering. Topics include energy and entropy, heat effects accompanying solution, flow of compressible fluids, refrigeration including solution cycles, vaporization and condensation processes, and chemical equilibria. Prerequisite: an introductory course in thermodynamics. Stein, Wenzel

401. Chemical Engineering Thermodynamics II (3) spring
A detailed study of the uses of thermodynamics in predicting phase equilibria in solid, liquid, and gaseous systems. Fugacities of gas mixtures, liquid mixtures, and solids. Solution theories; uses of equations of state; high-pressure equilibria. Stein, Wenzel

410. Chemical Reaction Engineering (3) spring
The application of chemical kinetics to the engineering design and operation of reactors. Non-isothermal and adiabatic reactions. Homogeneous and heterogeneous catalysis. Residence time distribution in reactors. Prerequisite: ChE 302. Klein, Georgakis

413. Heterogeneous Catalysis (3)
Surface area, pore structure and pore-size distribution of catalysis. Influence of pore-diffusion on catalytic reactions and the design of catalytic reactors. Chemical adsorption and physical adsorption. Chemistry, energetics and kinetics of adsorption, desorption, and surface reaction. Electronic structure and catalysis; atomic orbital and bondstructure models. Mechanisms of catalytic reactions of industrial importance. Selection and classification of catalysis. Stenger

415. Transport Processes (3) fall
A combined study of the fundamentals of momentum transport, energy transport and mass transport and the analogies between them. Evaluation of transport coefficients for single and multicomponent systems. Analysis of transport phenomena through the equations of continuity, motion, and energy. Caram, Silebi

419. (Mech 419) Asymptotic Methods in the Engineering Sciences (3)
Introductory level course with emphasis on practical applications. Material covered includes: Asymptotic expansions. Regular and singular perturbations; asymptotic matching. Boundary value problems; distinguished limits. Multiple scale expansion. W.K.B. Theory. Far field theories. Blythe

421. Heat Transfer (3)
Analysis of steady and unsteady state transfer. Convection, conduction, and radiation. Vaporization and condensation. Heat transfer in high velocity flow in rarified gases. Applications. Clump, Chen

427. (ME 427) Multiphase Heat Transfer (3)
Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation; dynamics of bubble growth and collapse; vapor-liquid cocurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow

boiling; simultaneous heat and mass transfer. Prerequisite: ChE 421 or ME 321, or courses in the area of transport phenomena. Chen

428. Rheology (3)
An intensive study of momentum transfer in elastic viscous liquids. Rheological behavior of solution and bulk phase polymers with emphasis on the effect of molecular weight, molecular weight distribution and branching. Derivation of constitutive equations based on both molecular theories and continuum mechanics principles. Application of the momentum equation and selected constitutive equations to geometries associated with viscometric flows. Silebi

430. Mass Transfer (3) spring
Theory and developments of the basic diffusion and mass transfer equations and transfer coefficients including simultaneous heat and mass transfer, chemical reaction and dispersion effects. Applications to various industrially important operations including continuous contact mass transfer, absorption, humidification, etc. Brief coverage of equilibrium stage operations as applied to absorption and to binary and multicomponent distillation. Caram, Silebi

433. (ECE 433, ME 433) State Space Control (3) fall
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin's Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal openloop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: M.E. 343 or E.C.E. 212 or Ch.E. 386 or consent of instructor. Johnson, Georgakis

434. (ECE 434, ME 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feedforward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: Ch.E. 433 or M.E. 433 or E.C.E. 433 or consent of instructor. Georgakis

436. (ECE 436, ME 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: Ch.E. 433 or M.E. 433 or E.C.E. 433 or consent of instructor. Johnson

437. (ECE 437, ME 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gausian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: Ch.E. 433 or M.E. 433 or E.C.E. 433 or consent of instructor.

440. Process Design (3)
Synthesis of flow sheets for various processes, investigation of contributions to overall economy of various alternatives. Evaluation of profitability of alternatives.

445. Enzyme Engineering (3)
Existing and potential industrial applications of enzymes. Enzyme characteristics including nomenclature, physical properties, kinetics and assay methods with emphasis on practical application at commercial scale. Practical commercial methods of enzyme production and purification. Design of industrial-scale reactors employing soluble enzymes. Immobilized enzymes; enzyme cofactor. Charles

450. Special Topics (1-12)
An intensive study of some field of chemical engineering not covered in the more general courses. Credit above three hours is granted only when different material is covered.

451. Problems in Research (1)
Study and discussion of optimal planning of experiments and analysis of experimental data. Discussion of more common and more difficult techniques in the execution of chemical engineering research.

455. Seminar (1-3)
Critical discussion of recent advances in chemical engineering. Credit above one hour is granted only when different material is covered.

460. Chemical Engineering Project (1-6)
An intensive study of one or more areas of chemical engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

461. Mathematical Methods in Chemical Engineering I (3)
Application of ordinary and partial differential equations to the solution of chemical engineering problems with emphasis on chemical reactions and transport processes as they occur in industrial chemical processing. Applications of solution in series, separation of variables, and integral transforms. Prerequisite: Math 322. Caram

464. Numerical Methods in Engineering fall
Survey of the principal numerical algorithms for: (1) functional approximation, (2) linear and nolinear algebraic equations, (3) initial and boundary-value ordinary differential equations and (4) elliptic, hyperbolic and parabolic partial differential equations. Analysis of the computational characteristics of numerical algorithms, including algorithm structure, accuracy, convergence, stability and the effect of computer characteristics, e.g., the machine epsilon and dynamic range. Applications of mathematical software in science and engineering. Schiesser

470. Cryogenic Engineering (3)
Liquefaction and separation of gases, physical and chemical principles. Low temperature thermometry. Insulation. Properties of fluids and of structural materials. The behavior of helium. Ultra-low temperature phenomena and theories. Wenzel

471. Low-Temperature Processes (3)
The problems and design of plants operating in the cryogenic temperature range. Refrigeration demands. Distillation and heat exchange at low temperatures. Analysis of processes for thermodynamic and operating efficiency. Problems of safety, non-steady state behavior and control. Wenzel

480. Research (3-4)
Investigation of a problem in chemical engineering.

481. Research (3-4)
Continuation of ChE 480.

482. (Chem 482, Mat 482) Engineering Behavior of Polymers (3)
A treatment of the mechanical behavior of polymers. Characterization of experimentally observed visocelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and

fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior.

483. (Chem 483) Emulsion Polymers (3) fall
Examination of fundamental concepts important in the manufacture, characterization, and application of polymer latexes. Topics to be covered will include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems. El-Aasser, Vanderhoff, Klein

484. (Chem 484) Crystalline Polymers (3)
An in-depth treatment of the morphology and behavior of both polymer single crystals and bulk crystallized systems. Emphasis is placed on the relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. A detailed discussion of the thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties. Prerequisite: ChE 392 or ChE 393 or equivalent.

485. (Chem 485) Polymers Blends and Composites (3)
An intensive study of the synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory course in polymers. Manson, Sperling

486. Polymer Processing (3)
Application of fundamental principles of mechanics, fluid dynamics and heat transfer to the analysis of a wide variety of polymer flow processes. A brief survey of the rheological behavior of polymers is also included. Topics include pressurization, pumping, die forming, calendering, coating, molding, fiber spinning and elastic phenomena. Prerequisite: ChE 392 or equivalent. Silebi

492. (Chem 492) Topics in Polymer Science (3)
Intensive study of topic selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: Chem 392 or equivalent.

Chemistry

Professors. G. Doyle Daves, Ph.D. (M.I.T.), *chairperson;* Robert S.. Sprague, Ph.D. (Illinois), *assistant chairperson;* Jack A. Alhadeff, Ph.D. (Oregon Medical School); Ned D. Heindel, Ph.D. (Delaware), *Howard S. Bunn Professor of Chemistry and director, Center for Health Sciences;* Kamel Klier, Ph.D. (Czechoslovak Academy of Science, Prague), *University Professor of Chemistry;* Charles S. Kraihanzel, Ph.D. (Wisconsin); John W. Larsen, Ph.D. (Purdue); Henry Leidheiser, Jr., Ph.D. (Virginia); Roland W. Lovejoy, Ph.D. (Washington State); John A. Manson, Ph.D. (McMaster, Ontario), *director of the polymer laboratory, Materials Research Center;* Joseph R. Merkel, Ph.D. (Maryland); Fortunato J. Micale, Ph.D. (Lehigh); William E. Ohnesorge, Ph.D. (M.I.T.); Steven L. Regen, Ph.D. (M.I.T.); Keith J. Schray, Ph.D. (Penn State); Gary W. Simmons, Ph.D. (Virginia), *director, Center for Surface and Coatings Research;* Donald M. Smyth, Ph.D. (M.I.T.), *director, Materials Research Center;* James E. Sturm, Ph.D. (Notre Dame); John W. Vanderhoff, Ph.D. (Buffalo), *director, Emulsion Polymers Institute, and associate director, Center for Surface and Coatings Research;* Thomas E. Young, Ph.D. (Illinois).
Associate professor. Michael J. Behe, Ph.D. (Pennsylvania); Daniel Zeroka, Ph.D. (Pennsylvania).
Assistant professor. Natalie Foster, Ph.D. (Lehigh); Linda J. Lowe-Krentz, Ph.D. (Northwestern); James E. Roberts, Ph.D. (Northwestern).
Adjunct and active emeritus professors. Eugene M. Allen, Ph.D. (Rutgers); Robert Eischens, Ph.D. (Northwestern); Frederick M. Fowkes, Ph.D. (Chicago); Courtland N. Robinson, Ph.D. (Utah); Albert C. Zettlemoyer, Ph.D. (M.I.T.).

Chemistry is a versatile subject area and the pursuit of a career in chemistry can be a most intellectually satisfying experience. No other basic science touches and shapes as many aspects of modern society as does chemistry. From soft contact lenses and synthetic blood to longer-lasting paint and alternative fuel sources, the study of chemistry has provided the solutions to complex problems and has improved the quality of all phases of human life.

That chemists at all levels of education find a market for their skills and knowledge in every employment area is further demonstration of the breadth of the science of chemistry. Chemists provide the technical backbone for the manufacturing industries (pharmaceuticals, plastics, paper, electronics, agriculture), for service industries (clinical and forensic laboratories, academe, environmental protection, information science) and for governmental positions in regulatory agencies and in science policy analysis. Many chemists are also employed in nontraditional areas—patent law, insurance underwriting, sales, product management, journalism, and even banking.

The alluring challenge of chemistry inspires many bachelor-degree holders to study for an advanced degree so that undergraduate preparation in chemistry enables future study within the discipline of chemistry and in other areas as well. Chemistry or biochemistry is the strongest preparation for graduate studies or professional school in the health-related disciplines (medicine, pharmacology, biochemistry) as well as for other science programs (materials science, polymers, environmental studies, mineralogy).

The study of chemistry opens doors to satisfying careers, to a stimulating view of the world, and to a professional life in which one's natural tendency to ask "why" can lead to personally rewarding endeavors.

The undergraduate curriculum in chemistry contains many of the prerequisites for biology, geological sciences, metallurgy, physics, and chemical engineering, so that students can normally transfer with no loss of credits at least through the sophomore year.

Chemistry students have the opportunity to design their undergraduate curricula for specialization in a variety of fields:

health-related chemistry (including premedical students)
suggested biology electives: 21, 22, 28, 235, 327, 353.
suggested chemistry electives: 336, 371, 372, 377, 378.
suggested physics elective: 367.

materials chemistry (polymers, solid state, surfaces)
suggested physics electives: 31, 363.
suggested chemistry electives: 312, 388, 392, 393, 394, 395, 396.

environmental chemistry
suggested biology electives: 21, 22, 135, 306, 309.
suggested chemical engineering electives: 320, 321.
suggested chemistry electives: 303, 333, 395.
suggested civil engineering electives: 371, 374.

geochemistry
suggested geology electives: 21, 133, 333, 334, 336, 352, 372.
suggested chemistry electives: 303, 396.

chemistry management
suggested accounting electives: 51, 52, 324.
suggested law elective: 201.

suggested management electives: 270, 302, 321 or 333.
suggested economics electives: 105, 119, 229.
suggested marketing electives: 211, 312.
suggested finance electives: 225, 330.

Certain of the above courses can be used to waive required graduate courses for the M.B.A. at Lehigh.

The Five-Year Program

Five-year programs are available for students to receive bachelor of science or bachelor of arts degrees and the master of science degree in several fields of chemistry (inorganic, organic, analytical, physical chemistry, polymers or biochemistry). Interested students should consult with the assistant department chairman about this at least one year before graduation.

B.S. and B.A. Degrees in Chemistry

Lehigh University offers a bachelor of science degree in chemistry from the College of Engineering and Applied Science and a bachelor of arts degree in chemistry from the College of Arts and Science. The required courses in science and mathematics are identical for the two programs as is the department's modern foreign language requirement. Both programs meet the certification standards of the American Chemical Society for an undergraduate degree in chemistry. The difference between the two programs lies in a differing recommended sequence and the difference between the Engineering College General Studies requirements and the Arts College distribution requirements. See notes following the recommended sequences of course requirements.

Effective July 1, 1987, the department of chemistry, traditionally associated with the College of Engineering, will be administered within the College of Arts and Science. Because the change is primarily related to the university's organization, students enrolled in existing chemistry degree programs will not be affected in their course work.

Bachelor of Science Degree in Chemistry

freshman year (see page 36) (31 credit hours)

Note: It is recommended that, where possible, students planning to major in chemistry take Chemistry 21/22 in the fall semester and Chemistry 31 in the spring semester of the freshman year. For such students the General Studies elective in the spring semester is displaced to a subsequent semester.

sophomore year, first semester (17 credit hours)

Chem 51	Organic Chemistry (3)
Chem 57	Organic Synthesis Laboratory (2)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Math 23	Analytic Geometry and Calculus III (4)
	modern foreign language requirement (3)*

*Chem. 31 Chemical Equilibria will displace this modern foreign language requirement to a subsequent semester if Chem. 31 was not taken in the freshman year.

sophomore year, second semester (17 credit hours)

Chem 52	Organic Chemistry (3)
Chem 54	Organic Chemistry Laboratory (2)
Chem 187	Physical Chemistry I (3)
Math 205	Linear Methods (3)
	modern foreign language requirement (3)
	general studies requirement (3)

junior year, first semester (17 credit hours)

Chem 188	Physical Chemistry Laboratory (2)
Chem 234	Analytical Chemistry Laboratory (1)
Chem 332	Analytical Chemistry (3)
Chem 341	Chemical Physics and Bonding (4)
Chem 358	Advanced Organic Chemistry (3)
Eco 1	Economics (4)

junior year, second semester (16 credit hours)

Chem 307	Advanced Inorganic Chemistry (3)
Chem 338	Advanced Chemical Analysis (2)
Chem 381	Radiation and Structure (3)
Chem 384	Advanced Chemical Experimentation (2)
	general studies requirement (6)

senior year, first semester (15 credit hours)

Chem 305	Representative Elements (2)
	free electives (10)
	general studies requirement (3)

senior year, second semester (15 credit hours)

	free electives (12)
	general studies requirement (3)

The program total credit hour requirement is 128.

Bachelor of Arts Degree in Chemistry

freshman year, first semester

Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Laboratory (1)
Math 21	Analytic Geometry and Calculus I (4)
	Engl. 1 (3)
	prelim. dist. elective (3)

freshman year, second semester

Chem 31	Chemical Equilibria in Aqueous Systems (3)
Math 22	Analytic Geometry and Calculus II (4)
Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Laboratory I (1)
	Engl. 2, 4, 6, 8 or 10 (3)

Note—Students who do not take Chem 21/22 in the first semester of the freshman year must take these courses in the second semester of the freshman year and must then take Chem 31 in the first semester of the sophomore year.

sophomore year, first semester

Chem 51	Organic Chemistry (3)
Chem 57	Organic Synthesis Laboratory (2)
Math 23	Analytic Geometry and Calculus III (4)
Engr 1	Engineering Computations (3) **or**
CSc 11	Introduction to Structured Programming (3)
	modern foreign language (3-4)

sophomore year, second semester

Chem 52	Organic Chemistry (3)
Chem 54	Organic Chemistry Laboratory (2)
Chem 187	Physical Chemistry I (3)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
	modern foreign language (3-4)

junior year, first semester

Chem 234	Analytical Chemistry Laboratory (1)
Chem 332	Analytical Chemistry (3)
Chem 305	Representative Elements (2)
	preliminary distribution electives (9)

junior year, second semester

Chem 338	Advanced Chemical Analysis (2)
Math 205	Linear Methods (3)
	upper class distribution electives (12)

senior year, first semester

Chem 188	Physical Chemistry Laboratory (2)
Chem 341	Chemical Physics and Bonding (4)
Chem 358	Advanced Organic Chemistry (3)
	upper class distribution electives (6)

senior year, second semester

Chem 307	Advanced Inorganic Chemistry (3)
Chem 381	Radiation and Structure (3)

Chem 384	Advanced Chemical Experimentation (2)
	upper class distribution elective (3)
	electives (3-6)

The minimum total hour requirement for the B.A. in Chemistry is 121.

Notes

1—Chemistry Department Modern Foreign Language Requirement—B.S. and B.A. Degrees

The Department of Chemistry requires each student to demonstrate competence in a modern foreign language which is useful in science. These are French, German, Russian and Japanese. Satisfactory completion of two semesters of study (6-8 cr) at the introductory level at Lehigh for the first three languages will meet this requirement. Instruction in Japanese is not given at Lehigh; however, demonstrated competence to read this language will be accepted to meet this requirement.

Students who can demonstrate reading competence equivalent to one or two semesters of introductory French, German or Russian at Lehigh can meet the departmental language requirement with less than 6-8 credits. In this case, other approved general studies or distribution courses must be taken to meet those requirements.

2—Unrestricted Electives

These are chemistry or non-chemistry courses which are taken to meet the total credit-hour requirement. Students are urged to use unrestricted electives to take certain chemistry courses related to any particular interests that have developed by their junior or senior years. See suggested elective programs in Health-related Chemistry, Materials Chemistry, Environmental Chemistry, Geochemistry and Chemistry Management.

Students who are interested in doing research are urged to take 6 credits of Chem. 375, Research Chemistry Laboratory. Students seeking departmental honors in Chemistry must take 6 credits of Chem. 375.

3—Difference between B.S. and B.A. Course Sequences

The B.S. sequence is designed to maximize undergraduate research opportunity in the senior year. The B.A. sequence is designed to spread the Arts College distribution requirements more appropriately throughout the four years. B.S. students can follow the B.A. sequence and vice-versa, depending on whether or not such students wish to do undergraduate research in the senior year.

Summary

Total Required Chemistry Hours—46
Total Required Hours—Physics, Math and Computer—28
Total Required Hours—Eng. Coll. G.S.—25*
Arts Coll. dist.—38*
Unrestricted elective hours—B.S.-29 (128 hour total)
B.A.-8 (120 hour total)

The minimum total hour requirement for graduation with a B.A. degree is 121. B.S. chemistry majors are expected to meet the 128 total hour requirement unless there are exceptional circumstances.

*Including 6-8 hours of modern foreign language if courses taken at Lehigh meet B.S. general studies or B.A. distribution requirements.

Minor in Chemistry

A minor in chemistry may be achieved by completing the following requirements:

Chem 31	Chemical Equilibria in Aqueous Systems (3)
Chem 51	Organic Chemistry (3)
Chem 53	Organic Chemistry Laboratory (1)
Chem 187	Physical Chemistry I (3)
Chem 192	Physical Chemistry Laboratory (2)
Chem 332	Analytical Chemistry (3)

Total Credits—15

Necessary pre- or co-requisites for the above would be Chem 21 and 22, Math 21 and Physics 11.

Students who wish to minor in chemistry but whose major program requires any of the above courses may achieve the minor with substitutions approved by the department chairman.

B.S. in Biochemistry

The undergraduate curriculum leading to a bachelor of science degree in biochemistry is based on the standard freshman year and the normal sophomore year of the chemistry curriculum.

Concentration in biochemistry courses takes place in the junior and senior years at the expense of some electives and of two courses in the normal chemistry curriculum. Consequently, graduates of this program are prepared to go into graduate work in several fields—medicine, biochemistry, chemistry, biophysics, and biology.

This curriculum requires 128 semester-hour credits. Students are expected to meet this total hour requirement unless there are exceptional circumstances.

Bachelor of Science Degree in Biochemistry

freshman year (see page 36 plus B.S. chemistry program) (31 credit hours)

sophomore year, first semester (17 credit hours)
same as B.S. chemistry program

sophomore year, second semester (17 credit hours)

Chem 52	Organic Chemistry (3)
Chem 54	Organic Chemistry Laboratory (2)
Chem 187	Physical Chemistry I (3)
Math 205	Linear Methods (3)
	biol elective (3)
	modern foreign language requirement (3)

junior year, first semester (17 credit hours)

Chem 371	Elements of Biochemistry I (3)
Chem 377	Biochemistry Laboratory (3)
Chem 234	Analytical Chemistry Laboratory (1)
Chem 332	Analytical Chemistry (3)
Chem 358	Advanced Organic Chemistry (3)
Eco 1	Economics (4)

junior year, second semester (17 credit hours)

Chem 372	Elements of Biochemistry (3)
Chem 192	Physical Chemistry Laboratory (2)
	biochem, biol or biophys elective (6)
	general studies requirement (6)

senior year, first semester (16 credit hours)

Chem 341	Chemical Physics and Bonding (4)
	biochem, biol or biophys electives (6)
	general studies requirement (6)

senior year, second semester (14 credit hours)

Chem 307	Advanced Inorganic Chemistry (3)
	biochem, biol or biophys electives (3)
	free electives (5)
	general studies requirement (3)

The program total hour requirement is 128.

Notes—Biochemistry majors must meet the Chemistry Department modern foreign language requirement. Biochemistry majors who wish to have their degree certified by the American Chemical Society must take Chem 338 and Chem 305 among their electives.

Biology electives include Biol 21, 22, 28, 235, 327, 353 or others approved by the adviser; nine credits required. Biophysics electives include Phys 367, Chem 303 or others approved by the adviser; three credits required. Biochemistry electives include Chem 375, 378, Ch.E 341 or others approved by the adviser; two credits required.

Summary—
Total Required Hours—Chemistry—46
Total Required Hours—Physics, Math, Computer—28
Total Required Hours—Biochem, Biol,
Biophys—electives—18
Total Required Hours—Eng. Coll. G.S.—25
Unrestricted elective hours—11

Undergraduate Courses in Chemistry

21. Introductory Chemical Principles (4) fall-spring
An introduction to important topics in chemistry. These include atomic structure, bonding in inorganic and organic compounds, states of matter, chemical equilibrium, acid-base theories and electrochemistry. Prerequisite: Math 21,31 or 41 previously or concurrently. Three lectures, one recitation.

22. Chemical Principles Laboratory (1) fall-spring
A laboratory course to be taken concurrently with Chem 21. One three-hour laboratory period per week.

23. Environmental Aspects of Analytical Chemistry (3) spring
The fundamentals, theory, and practice of the analytical chemical methods used to examine air, water, and soil samples for trace impurities. Selected topics in the areas of classical and instrumental methods. Prerequisite: Chem 21.

31. Chemical Equilibria in Aqueous Systems (3) fall-spring
A study of the theoretical basis and practical applications of equilibria in aqueous solutions, including acid-base, precipitation-solubility, metal-ligand, oxidation-reduction and distribution equilibria. Introduction to chemical thermodynamics, spectrophotometry, potentiometry and chromatography. The laboratory work emphasizes the qualitative and quantitative analysis of equilibria in aqueous media. Prerequisite: Chem 21, Math 21; Phys 11 previously or concurrently. Two lectures and one three-hour laboratory period.

51. Organic Chemistry (3) fall
Systematic survey of the typical compounds of carbon, their classification, and general relations; study of synthetic reactions. Prerequisite: Chem 21.

52. Organic Chemistry (3) spring
Continuation of Chem 51. Prerequisite: Chem 51.

53. Organic Chemistry Laboratory (1) fall
Preparation of pure organic compounds. Modern techniques of characterization. Cannot be taken by chemistry or biology majors to fulfill a major requirement. Only one lab course among Chem 53, 55, or 57 may be taken for credit. Prerequisite: Chem 21; Chem 51 previously or concurrently.

54. Organic Chemistry Laboratory (2) spring
Continuation of Chem 57 with particular emphasis upon aromatic compounds and qualitative organic analysis, using modern instrumental techniques. Prerequisite: Chem 57 previously; Chem 52 concurrently.

55. Organic Chemistry Laboratory (2) spring
Preparation of pure organic compounds and the techniques of organic chemistry applicable to both aliphatic and aromatic compounds. Intended for biology majors. Only one lab course among Chem 53, 55, or 57 may be taken for credit. Prerequisite: Chem 51; Chem 52 concurrently.

57. Organic Synthesis Laboratory (2) fall
Methods of preparation, purification and characterization of organic compounds. Modern techniques of chromatography and instrumentation are involved in characterization. Restricted to chemistry majors. Only one lab course among Chem 53, 55, or 57 may be taken for credit. Prerequisite: Chem 21; Chem 51 previously or concurrently.

187. Physical Chemistry I (3) spring
Development of the principles of thermodynamics and their application to systems in which composition is of major concern: solutions, chemical and phase equilibria. Elements of chemical reaction kinetics. Prerequisite: Chem 31 or Met 210, and Math 21 or 43 previously or concurrently.

188. Physical Chemistry Laboratory (2) fall
Primarily for majors in chemistry. Quantitative observation of properties of matter and of dynamic processes involving composition and the relation of observations to conceptual models. Methods of data acquisition, treatment, assessment. Prerequisite: Chem 187.

189. Physical Chemistry II (3) fall
A continuation of Chemistry 187. Kinetic theory of gases, statistical thermodynamics, electrolytes in solution, electrochemistry, corrosion, colloid and surface chemistry and the solid state. Prerequisites: Chem 187, Math 23, Phys 21.

192. Physical Chemistry Laboratory (2)
Laboratory studies that illustrate the various fields of study in experimental physical chemistry. Prerequisite: Chem 187.

193. (Biol 191, Geol 191) Environmental Science Seminar (1) fall and spring
Current developments in environmental science presented by students and discussed in semainar style. An interdisciplinary approach linking biological, geological, and chemical principles as they relate to causes and controls of environmental problems. May be taken more than once for credit. Prerequisite: sophomore standing.

194. Physical Chemistry for Biological Sciences (3) fall
The principles and applications of physical chemical concepts to systems of biological interest, including the gas laws, thermodynamics of metabolic reactions, colligative properties, electrochemical equilibria, reaction kinetics and enzyme catalysis, and transport of macromolecules and viruses. Prerequisite: Chem 21.

207. Metallic Elements (3) fall
A systematic study of the inorganic chemistry of the metallic elements and their major compounds with emphasis on the properties and structures of solid materials. Grouping of elements with similar properties within the periodic table is stressed. Prerequisite: Chem 21. Smyth

234. Analytical Chemistry Laboratory (1) fall
Laboratory course: experiments coordinated with and illustrating methods and principles discussed in Chem 332. Ohnesorge

250. Special Topics (1-3)
Selected topics in chemistry. May be repeated for credit when different topics are offered.

303. Nuclear and Radiochemistry (3)
A broad survey of nuclear science with particular emphasis on aspects of importance to chemistry and biology. Elementary nuclear theory, production, separation, and identification of radioactive and stable isotopes; use of isotopes in the study of chemical and biological systems;radiological safety; nuclear engineering. Two lectures and one lecture-laboratory. Prerequisite: Chem 187 or Chem 194, or consent of the department chairperson. Sturm

305. Representative Elements (2) fall
The chemical and physical properties of the representative elements and their hydrides, oxides and halides. Material will include pertinent aspects of acid-base theories, non-aqueous solvents, the diagonal relationships and inorganic polymers. Prerequisite: Chem 187.

307. Advanced Inorganic Chemistry (3) spring
Selected topics in inorganic chemistry. Descriptive chemistry of the representative elements; introduction to transition metal complexes and the theories of bonding in these substances;

kinetics and mechanisms of transition metal complex reactions; selected aspects of organometallic chemistry; bioinorganic chemistry. Prerequisite: Chem 341.

312. (ChE 312, Mat 312) Fundamentals of Corrosion (3) fall
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization and passivity. Nonelectrochemical corrosion including mechanisms, theories and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings alloys, inhibitors, and passivators. Prerequisite: Met 210 or Chem 187. Leidheiser

332. Analytical Chemistry (3) fall
Theory and practice of chemical analysis. Principles of quantitative separations and determinations; theory and application of selected optical and electrical instruments in analytical chemistry; interpretation of numerical data, design of experiments, solute distribution in separation methods. Prerequisites: Chem 31 and 51. Ohnesorge

333. Environmental Chemistry (3) fall
A survey of the chemistry of aquatic systems (fresh, saline and ocean), the atmosphere and soils based on equilibrium, thermodynamics and kinetics principles and acid-base, precipitation-dissolution, oxidation-reduction and complexation chemistry. Prerequisites: Chem 51, Chem 187.

336. Clinical Chemistry (3) spring
Applications of analytical chemistry to clinical problems. Discussion of methods in common use and the biochemical-medical significance of the results. Prerequisites: Chem 332 and 52. Ohnesorge, Schray

337. (Geol 337, Mat 333) X-ray Diffraction of Materials (3) fall
Emphasis on materials characterization with computer-controlled powder diffractometers. Specific topics include x-ray spectroscopy, crystallographic notation, orientation of single crystals, preferred orientations in polycrystals, crystallite size measurement, phase identification, quantitative analysis of crystalline phases, and stress measurement. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisite: consent of department chairperson. Lyman

338. Advanced Chemical Analysis (2) spring
A lecture-laboratory course in continuation of Chem 234 and 332 emphasis on spectrochemical, electroanalytical and chromatographic techniques. Prerequisites: Chem 234, 332.

341. Chemical Physics and Bonding (4) fall
Development of ideas relating to the nature of the chemical bond. Emphasis placed on the quantum chemistry of atoms and molecules. Statistical thermodynamics of gaseous and solid systems. Diffraction effects in crystalline solids. Properties of the liquid state. Macromolecules. Prerequisites: Chem 187, Math 205, Physics 21.

350. Special Topics (1-3)
Selected advanced topics in chemistry. May be repeated for credit when different topics are offered.

358. Advanced Organic Chemistry (3) fall
The study of modern theories of reaction mechanisms and their applications to the problems of organic chemistry. Prerequisite: one year of organic chemistry. Young

368. Advanced Organic Laboratory (2)
The synthesis and study of organic compounds illustrating the important techniques and special pieces of apparatus commonly used in organic chemical research. Prerequisite: one year of organic chemistry and laboratory.

371. (Biol 371) Elements of Biochemistry I (3) fall
A general study of carbohydrates, proteins, lipids, nucleic acids, and other biological substances and their importance in life processes. Protein and enzyme chemistry are emphasized. Prerequisite: one year of organic chemistry.

372. (Biol 372) Elements of Biochemistry (3) spring
Dynamic aspects of biochemistry: enzyme reactions including energetics, kinetics and mechanisms, metabolism of carbohydrates, lipids, proteins and nucleic acids, photosynthesis, electron transport mechanisms, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chem 371.

375. Research Chemistry Laboratory (1-6) fall-spring
Advanced independent study or an investigation involving intensive work with faculty guidance in laboratory and library. Topics in active research in biochemistry, analytical, inorganic, organic and physical chemistry. Prerequisite: consent of the department chairperson.

377. Biochemistry Laboratory (3) fall
Laboratory studies of the properties of chemicals of biological origin and the influence of chemical and physical factors on these properties. Laboratory techniques used for the isolation and identification of biochemicals. Prerequisite: Chem 371, previously or concurrently. Merkel or Alhadeff

378. Biochemical Preparations (1-3) spring
A laboratory course involving the preparation or isolation, purification and identification of chemicals of biological origin. Prerequisites: Chem 377 and 372, previously or concurrently. Merkel or Alhadeff

381. Radiation and Structure (3) spring
Quantum chemistry and group theory applied to molecular orbital theory of bonding, structure, and spectroscopy. Study of selection rules for chemical and photochemical reactions. Prerequisites: Chem 341 and Math 205. Klier

382. Spectroscopy and Photochemical Kinetics (3) spring
Applications of electronic, infrared, and microwave spectroscopy to the study of molecular structure. Chemical consequences of intramolecular excitation; quantum efficiences and reaction mechanisms; pulse excitation and dynamics of elementary processes. Prerequisite: Chem 341. Lovejoy, Sturm

384. Advanced Chemical Experimentation (2) spring
An advanced laboratory course for chemistry majors which integrates library research, chemical syntheses, separations, purification methods, physical techniques and spectral characterization in the pursuit of mini-research problems in the areas of inorganic or organometallic chemistry. Written and oral reports will be required. Prerequisite: Junior standing

385. Physical Chemistry of Printing Inks (3) fall
Physical chemical mechanisms of printing processes; composition, dispersion processes for pigments rheology and printability of inks; color-matching; development of solventless inks and specialty inks. Prerequisite: Chem 187 or equivalent. Vanderhoff

388. (ChE 388) Polymer Synthesis and Characterization Laboratory (3) spring
Techniques include: free radical and condensation polymerization; molecular weight distribution by gel chromatography; crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior; morphology and microscopy; surface properties. Prerequisite: Chem 187, 189 or 341 and 51. Manson, El-Aasser

392. (ChE 392) Introduction to Polymer Science (3) spring
Introduction to concepts of polymer science. Kinetics and mechanisms of polarization; synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties. Prerequisite: Chem 187 or equivalent. Manson, Sperling

393. (ChE 393, Mat 343) Physical Polymer Science (3) fall
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline and paracrystalline states (including visoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: one year of physical chemistry. Manson, Sperling

394. (ChE 394) Organic Polymer Science (3) spring
Organic chemistry of synthetic high polymers. Functionality and reactivity of monomers and polymers. Theory of stepgrowth and chain-growth polymerization in homogenous and heterogenous media. Polymerization by addition, elimination, substitution and coupling reactions. Ionic, free-radical and coordination catalysis. Prerequisite: one year of physical chemistry and one year of organic chemistry. Manson,Vanderhoff

395. Colloid and Surface Chemistry (3) fall
Physical chemistry of everyday phenomena. Intermolecular forces and electrostatic phenomena a interfaces, boundary tensions and films at interfaces, mass and charge transport in colloidal suspensions, electrostatic and London forces in disperse systems, gas adsorption and heterogeneous catalysis. Prerequisite: Chem 187 or equivalent. Fowkes, Micale

396. (Mat 396) Chemistry of Nonmetallic Solids (3) spring
Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity controlled defects nonstoichiometric compounds, defect interactions. Properties to be discussed include: diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: Chem 187 or Met 210 or equivalent. Smyth

Graduate Programs in Chemistry

The department of chemistry offers graduate studies leading to several advanced degrees. These include master of science and doctor of philosophy degrees in chemistry, a doctor of arts in chemistry, master of science and doctor of philosophy degrees in physiological chemistry and a master of science in clinical chemistry. Master of science and doctor of philosophy degrees in chemistry may be obtained by study and research in the following areas of chemistry—analytical, biochemistry, inorganic, organic, physical and polymers. Additional information concerning the physiological chemistry and clinical chemistry programs may be obtained from Section IV of this catalog. The doctor of arts degree includes broad course work in many of the major subdisciplines of chemistry and requires two areas of specialization. A laboratory problem in chemistry (at the M.S. level) and a chemical education project (at the doctoral level) are required. A teaching internship (Chem 411) and an industrial externship are part of the degree program—a program which is particularly intended to upgrade college teachers presently employed in academia but not holding the doctorate.

The chemistry department also admits students to the master of science and doctor of philosophy degree programs in molecular biology and polymer science and engineering. These are interdisciplinary programs which are described in Section IV of this catalog and are *not* administered by the chemistry department. The following information on admissions, proficiency examinations and other policies applies to all of the programs listed above but not to the molecular biology and polymer science and engineering programs.

Admission to graduate study in chemistry assumes that a student has met, or is willing to meet though further study, minimum undergraduate requirements for a bachelor's degree in chemistry. This would include (beyond two semesters of introductory chemistry) two semesters of organic chemistry, two semesters of physical chemistry, two semesters of analytical chemistry and one semester of inorganic chemistry. A promising student whose degree is in a field related to chemistry (e.g., biology, chemical engineering) may be admitted to graduate study in chemistry provided that any deficiencies in basic chemistry preparation are made up in the first year of graduate study and noting that some of the courses required for this may not carry graduate credit.

The Chemistry Department will administer proficiency examinations in analytical, biochemistry, inorganic, organic and physical chemistry to all regular graduate students at the time of matriculation. Each student is required to take three examinations. Information regarding material to be covered on these examinations will be sent to each student several months in advance of matriculation. It is expected that each student will prepare diligently for these tests. A student who performs well on one or more of these tests has an opportunity to take advanced level and special topics courses at an earlier than normal time and may in fact begin graduate research during the first year. A Ph.D. candidate must show proficiency in three areas and an M.S. candidate in two areas within the first year in residence. A student who fails one or more of the proficiency examinations will meet with the department Graduate Advisory Committee to determine an appropriate course of action in light of the exam performance, projected major and degree aspiration. Two optional routes are available for demonstration of proficiency. (1) The student through self-study and auditing of appropriate courses may prepare for a retaking of a proficiency examination at the beginning of the second semester in residence. (2) Alternatively, the student may enroll in appropriate 300 or 400 level courses during the first year in residence. A grade of B⁻ or better in an appropriate 300-400 level course will be considered equivalent to passing the proficiency examination in that area. Courses taken as a means of demonstrating proficiency will be acceptable on the M.S. or Ph.D. graduate program.

Work for the master's degree requires at least 30 credits—a minimum of 24 course credits and 6 credits of research (which may involve either a laboratory or literature research project). There are no required courses for the M.S., once proficiency has been established. The courses taken are those deemed appropriate for the student's area of concentration. There is a one credit seminar requirement for the M.S. Normally, work for the master's degree can be completed in 1½ calendar years.

Completion of a doctor of philosophy degree program normally requires a minimum of four years full-time work after entrance with a bachelor's degree. There are no specific course credit requirements for the Ph.D.; however, approved degree programs generally have at least 30 hours of course work (including any applied toward a master's degree) and 6 credits of research. Thus, the program consists of approximately one-third formal course work and two-thirds independent study and research. There is a foreign language requirement for the Ph.D. First year college proficiency in one of the four languages—French, German, Russian or Japanese—must be established on some basis. There is also a two credit seminar requirement. After Ph.D. proficiency has been established and the research advisor selected (this must be done by the end of the first year in residence), the major hurdles are the doctoral examinations (both written and oral) in the student's area of concentration which must be passed by the end of 2½ years of residence. If this hurdle is surmounted, the remaining time is spent completing (and ultimately defending) the thesis research under the guidance of the research adviser and the thesis committee.

Most of the chemistry facilities are housed in the 90,000-square-foot chemistry complex, first occupied in 1975. The seven-story Seeley G. Mudd Building affords laboratory space of modern design; the top three floors are devoted to research laboratories. Most of the research laboratories in the adjacent Sinclair Laboratory are assigned to chemistry professors who specialize in research in surface and colloid chemistry.

Physiological chemistry research is located in Chandler-Ullmann Hall and in the Seeley G. Mudd Building. Solid-state chemical research is located in the Sherman Fairchild Laboratory, in Coxe Laboratory, in the Seeley G. Mudd Building, and in Sinclair Laboratory. Polymer chemistry research laboratories are located in Coxe Laboratory, Sinclair Laboratory, and the Seeley G. Mudd Building.

Current Research Projects

Current research projects of interest are listed below.

Analytical chemistry. Gas chromatograph-mass spectroscopy of trace organics, electrochemical reduction and oxidation mechanisms of organic compounds, clinical-biomedical applications, mechanisms of electrode processes, adsorption; redox behavior of transition metal complexes; luminescence of metal-ion complexes in organized media.

Biochemistry. Production, isolation and characterization of proteolytic enzymes of marine bacteria; determination of the amino acid specificity of bacterial proteases; mechanism of action of proteolytic enzymes; collagenolytic enzymes of bacteria; factors affecting collagenase production of bacteria and tissues in culture; characterization of lysosomal glycosidases and glycosyltransferases; functional role of carbohydrates in glycoproteins; abnormal glycoprotein metabolism in human diseases; synthesis and characterization of novel polynucleotides; sequence dependence of the B-Z transition of DNA; non-isotopic immunoassays; protein surface binding phenomena; development of *in vitro* evaluation techniques for prescreening candidate pharmaceuticals; structural dynamics and molecular associations of biologically significant molecules; relaxation phenomena in NMR and the development of contrast enhancement agents for medical imaging.

Inorganic chemistry. Synthesis, characterization and chemistry of transition metal organometallic complexes with alkyl, carbonyl, nitroso, dinitrogen, dioxygen and phosphine ligands. Addition reactions of the benzene-Cu(I) complex. Applications of molecular mechanics and molecular orbital theories in studies of inorganic and organic derivatives of the representative elements and transition metals. Synthesis of solid catalysts including oxides, sulfides, zeolites and supported metals. Solid state chemistry of dielectric and electro-optic oxides. Defect chemistry and non-stoichiometry of transition metal oxides.

Organic chemistry. Synthesis of medicinal agents, correlation of molecular structure with pharmacological behavior; chemical models for biochemical reactions; biosyntheses involving indole intermediates; mechanism of formation and structure of melanin; synthesis of new heterocyclic systems; mechanisms of phosphoglucose isomerase and aldolase; synthesis and phosphoryl transfer of phosphate esters of biological interest; radio pharmaceuticals; organic reactions in molten salts.

Physical chemistry. Colloid and surface research include latexes, surface coatings, colloidal stability, adhesion, surface properties of catalysts relating powder flow to their surface chemistry, water at surfaces, fundamental studies of gas-solid surface reactions, printing inks, chemical reactions in small confined volumes, microcalorimetric and FTIR spectrometric studies of Lewis acid-base interactions at interfaces and surface spectroscopy. Solid-state chemistry includes studies of point defects in oxides and oxide growth. Other fields include photochemical dynamics, applications of very high resolution infrared spectroscopy to analytical problems of vibration-rotation lines, nuclear magnetic resonance and applications of quantum mechanics and statistical mechanics to problems of chemical interest. Role of ionic bonding in the macromolecular structure of coals. Stabilities of homoconjugated carbocations. Thermodynamics of formation of organic intermediates. Coal chemistry. Electrostatics of non-aqueous systems. Single crystal vibrational and electron surface spectroscopy; structure-function relationships in catalysis; intrazeolitic transition metal ion complexes-spectroscopy, structure and reactivity; kinetics of heterogenously catalyzed reactions.

Polymer chemistry. Synthesis, structure, conformation and properties of high polymers; techniques and kinetics of emulsion polymerization and film formation; acoustic, optical, permeability, dielectric and mechanical behavior of thin films, coatings and bulk polymers; molecular structure, relaxation behavior and energetics of fracture; elastic and viscoelastic behavior of interpenetrating and rubbery networks; effects of ordering in the glassy state and crystallization on physical properties; crystallization under the influence of shear gradients; physical chemistry of polymer composites such as polymer-concrete and filled polymers; interfacial characteristics and interactions in polymer-inorganic systems; mechanical properties of polymer printing plates; NMR studies of polymers in aqueous solutions and gels; ionic motion through polymer films.

Major Instrumentation

Special equipment available for graduate research in chemistry is as follows:

Biochemistry facilities—laboratory fermentor, cold rooms, cell disintegrator, Warburg respirometer, zone and disc electrophoresis apparatus, paper column chromatograph, autoclave, ultra-low temperature freezers (−90° and −135° C), rotary vaporator, Milli-Q water purification system, shaking heated water baths. Catalytic high pressure reactors—fully automated with on-line gas chromatographs. Cell culture facilities—complete with optical microscopes having fluorescent and photographic capabilities, liquid scintillation equipment. Coal research and analysis facility—complete with ultracentrifuge, gas chromatographs, gel permeation chromatograph, vapor pressure osmometer, dry boxes. Electron microscope—scanning electron microscope-microprobe. Electrophoresis apparatus—automatic. Ellipsometer. Gas adsorption apparatus. Gas chromatographs, including a PE sigma 3 for inverse gas chromatography. Kinetics apparatus—temperature jump method. Liquid chromatographs—high performance for analytical and preparative work. Microcalorimeter—flowing with UV and refractive index detectors. NMR spectrometers—90 MHz multinuclear Fourier transform, 300 MHz solid state, 500 MHz solution state. Photochemistry equipment—lamps and filters for selected wavelength work. Polarographs and chronopotentiometers—recording multipurpose. Radio-tracer equipment, including a gamma counter. Refractometer—differential. Rheometer—Bohlin VOR. Surface analysis analyzer (BET). Spectrometers—uv/visible double beam automated, uv/visible/near ir automated, Fourier transform ir with diffuse reflectance and photoacoustic capability, tunable diode laser ir, Raman microprobe, GC mass spectrometer, fluorometers, phosphorescence, electron spin resonance, Auger, Mossbauer, ESCA, x-ray photoelectron (XPS), low-energy electron diffraction, high resolution electron energy loss, light scattering, electrochemical impedance, photocorrelation for submicron particle analysis. Spectropolarimeter with circular dichroism capability. Tester for power compacts—tensile and compressive. Thermister calorimeter for heats of immersion. Titration equipment—automated and computer interfaced. Vibron elastoviscometers.

Graduate Courses in Chemistry

402. Physical Inorganic Chemistry (3) alternate years
Theories of bonding. Group theoretical principles will be utilized in studies of molecular orbital and ligand field theories of bonding. Prerequisite: Chem 341 or equivalent. Klier

403. Advanced Topics in Inorganic Chemistry (1-3) alternate years
Topics of contemporary interest in inorganic chemistry. This course may be repeated when a different topic is offered. Prerequisite: Chem 307 or equivalent.

405. Organometallic Chemistry (3) alternate years
The chemistry of compounds containing carbon to metal bonds. Among topics covered are the following: organic compounds of the representative elements from Group I to IV; the chemistry of ferrocene and related pi-bonded organometallic complexes; metal carbonyl and nitrosyl

complexes; dioxygen and dinitrogen complexes; organic synthesis utilizing organometallic catalysts. Kraihanzel

411. Teaching Internship (3-6) fall-spring
The preparation, teaching and grading of one or two undergraduate lecture courses with appropriate supervision by senior faculty members. Observation and evaluation of the intern is effected by classroom visits and vidotape review. Prerequisite: candidacy in the doctor of arts program or permission of the department chairperson. May be repeated for credit.

421. Chemistry Research (1-4)
Research in one of the following fields of chemistry; analytical, inorganic, organic, physical, polymer, biochemistry.

423. Bio-organic Chemistry (3) alternate years
An examination of biochemistry on the basis of organic chemical principles. Emphasis on reaction mechanisms of biochemical transformations and methods for elucidation of these mechanisms, ie., kinetics, isotope effects, exchange techniques, inhibition studies, substrate analog effects and organic model studies. Prerequisite: Chem 358. Schray

424. Medicinal and Pharmaceutical Chemistry (3) alternate years
Principles of drug design, structure-activity relationships in antibacterial, antimalarial, anti-inflammatory and psychoactive drugs; synthesis and modes of action of pharmacologically active agents radioactive pharmaceuticals. Prerequisite: one year of organic chemistry. Heindel

432. Advanced Analytical Chemistry (3) alternate years
Recent developments in analysis of chemical methods. Statistical methods in analytical chemistry: treatment and interpretation of numerical data; design of experiments; application to and discussion of multistage and other methods for separating chemical species. Prerequisite: Chem 332 or equivalent. Ohnesorge

433. Advanced Topics in Electrochemistry (3) alternate years
Theory and applications of selected electrochemical techniques; solutions to mass transport problems, treatment of electron transfer kinetics and kinetics of associated chemical reactions, and critical evaluation of adsorption and other factors associated with electrochemical processes. Prerequisite: Chem 332 or equivalent. Ohnesorge

435. Advanced Topics in Clinical Chemistry (3)
Selected aras of clinical chemistry such as chemical toxicology, pathogenic microbial biochemistry in vivo diagnostic methodology, therapeutic drug monitoring, or other advanced topics. May be repeated for credit when a different topic is offered.

436. Special Topics in Analytical Chemistry (1-3)
Topics of contemporary interest in analytical chemistry. May be repeated for credit when a different topic is offered. Ohnesorge, Simmons, Daves

437. Pathophysiological Chemistry (3) spring
Biochemical basis of human diseases involving abnormal metabolism of proteins, nucleic acids, carbohydrates, and lipids. Emphasis on the correlation of the clinical presentation of disease processes seen as physiological dysfunctions with clinical laboratory methods. Lectures, student presentations, and clinical case discussions. Prerequisite: consent of the department chairperson. Alhadeff

441. Chemical Kinetics (3) alternate years
A study of kinetic processes. Phenomenological chemical kinetics; order, mechanism effect of external variables on rate. Theories of the rate constant. Relation betweeen thermodynamics and kinetics. Applications to selected systems such as unimolecular decompositions, molecular beams and diffusion-limited processes. Prerequisite: one year of physical chemistry. Sturm

443. (Mat 443) Solid-State Chemistry (3) alternate years
Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids dielectrics, surface states and surface fields in crystals. Prerequisite: one course in linear algebra and one course in quantum mechanics. Klier

445. Elements of Physical Chemistry (4) spring
Quantum chemistry of simple systems, molecular structure and spectroscopy, statistical and classical thermodynamics, and principles of kinetic processes. Lovejoy, Sturm, Zeroka

447. (Biol 447, Phys 447) Experimental Molecular Biology (3)
The evolution, structure, replication or expression of genes in prokaryotes and eukaryotes. Lectures, discussions, and experiments on the application of genetic analysis and recombinant DNA technology to fundamental aspects of molecular biology.

451. Physical Organic Chemistry (3) alternate years
An introduction to quantitative organic chemistry including relationships between structure and reactivity, medium effects on reactions, introduction to orbital symmetry effects in organic reactions, and reaction mechanisms. Prerequisite: Chem. 358 or consent of department chairperson. Larsen

453. Heterocyclic Compounds (3) alternate years
An intensive study of the syntheses, reactions and properties of heteroaromatic compounds including derivatives of thiophene, pyrrole, furan, indole, pyridine, quinoline, the azoles and the diazines-all considered from the viewpoint of modern theories of structure and reaction mechanisms. Prerequisite: Chem 358. Young

455. Organic Synthesis (3) alternate years
Principles of organic synthesis; retrosynthetic analysis, convergent vs. linear sequences, control of relative stereochemistry, chiral substrates and reagents. These and other principles will be illustrated using examples from the recent literature. Prerequisite: Chem. 358 or consent of department chairperson. Daves

458. Topics in Organic Chemistry (3)
An intensive study of limited areas in organic chemistry. May be repeated when a different topic is offered.

466. Advanced Organic Preparations (2-3)
A laboratory course of instruction in advanced techniques of the preparation of organic compounds.

473. Biochemistry of Complex Carbohydrates (3) alternate years
Consideration of the structure, function and metabolism of complex carbohydrates (glycolipids, glycoproteins and proteoglycans) with particular emphasis on glycoproteins. The first part of the course will consist of lectures to familiarize the student with basic terms, concepts and processes. The second part will involve critical readings, presentation and discussion of the current primary research literature by class participants. Alhadeff

475. Advanced Topics in Chemistry (1)
Audiovisual courses in topics such as acid-base theory, NMR, chromatography, electroanalytical chemistry and mass-spectroscopy interpretation; course material obtained from the American Chemical Society. May be repeated for credit.

476. Microbial Biochemistry (3)
Composition, nutrition and metabolism of microorganisms. Major emphasis will be placed on bacteria: the nature of the macromolecules which go into their structures; assembly processes, generation of energy by photosynthetic or chemosynthetic processes, metabolism and control of metabolic reactions. Prerequisite: Chem 372 or equivalent. Merkel

477. Topics in Biochemistry (1-3)
Selected areas of biochemistry, such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins. May be repeated for credit when different topics are offered. Prerequisite: consent of the department chairperson.

479. Biochemical Techniques (3)
Laboratory studies of the techniques and principles involved in the isolation, identification, and biochemical transformation of carbohydrates, lipids, nucleic acids and proteins. Prerequisite: Chem 371 or its equivalent previously or concurrently. Merkel or Alhadeff

480. Advanced Biochemical Preparations (1-3)
An advanced laboratory course in the preparation, isolation, purification, and identification of biochemically produced materials. Emphasis is placed on materials and procedures of current interest in biochemistry. Prerequisite: consent of the department chairperson. Merkel or Alhadeff

481. Chemistry Seminar (1-6)
Student presentations on current research topics in the student's discipline but not on subjects close to the thesis. A one-hour presentation and attendance at othe presentations are required for credit. May be repeated for credit, up to six times.

482. (ChE 482, Mat 482) Engineering Behavior of Polymers (3) spring
Mechanical behavior of polymers. Characterizaion of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizer, moisture, and aging on mechanical behavior. Robinson

483. (ChE 483) Emulsion Polymers (3) fall
Fundamental concepts important in manufacture, characterization, and application of polymer latexes. Topics include colloidal stability, polymerization mechanisms and kinetics, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various application problems. Prerequisite: previous course in polymers. Vanderhoff

484. (ChE 484, Mat 484) Crystalline Polymers (3) spring
Morphology and behavior of both polymer single crystals and bulk crystallized system. Relationship between basic crystal physics, thermal and annealing history, orientation and resulting properties. Thermodynamics and kinetics of transition phenomena and a brief treatment of hydrodynamic properties and their relationship to crystallization and processing properties.

485. (ChE 485, Mat 485) Polymer Blends and Composites (3) fall
Synthesis, morphology and mechanical behavior of polymer blends and composites. Mechanical blends block and graft copolymers, interpenetrating polymer networks, polymer impregnated solids and fiber and particulate-reinforce polymers are emphasized. Prerequisite: any introductory course in polymers. Manson, Sperling

487. Topics in Colloid and Surface Chemistry (3)
Applications of colloid chemistry; special topics in surface chemistry. Lectures and seminar. May be repeated for credit as different topics are covered. Prerequisite: Chem 395. Fowkes, Micale, Vanderhoff

488. Advanced Topics in Physical Chemistry (1-3)
Advanced topics in physical chemistry, such a photochemistry and molecular beam dynamics. Fourier transform spectroscopy, kinetics of rapid reactions, theory of magnetic resonance. May be repeated for credit when different topics are offered.

492. (ChE 492) Topics in Polymer Science (3)
Intensive study of topics selected from areas of current research interest such as morphology and mechanical behavior, thermodynamics and kinetics of crystallization, new analytical techniques, molecular weight distribution, non-Newtonian flow behavior, second-order transition phenomena, novel polymer structures. Credit above three hours is granted only when different material is covered. Prerequisite: Chem 392 or equivalent.

494. Quantum Chemistry (3) alternate years
Principles and applications of quantum mechanics to chemical problems. Applications to chemical bonding, molecular structure, reactivity and spectroscopy. Prerequisite: Chem 445 or consent of the department chairperson. Zeroka

495. Statistical Thermodynamics (3) alternate years
Principles and applications of statistical mechanics to chemical problems. A study of the techniques for evaluating the properties of matter in bulk from the properties of molecules and their interactions. Prerequisite: Chem 445 or consent of the department chairperson. Zeroka

Chinese

See listings under Modern Foreign Languages.

Civil Engineering

Professors. Irwin J. Kugelman, Sc.D (M.I.T.), *chairman, director, Center for Marine and Environmental Studies;* Lynn S. Beedle, Ph.D. (Lehigh), *director, Institute for the Study of High-Rise Habitat;* J. Hartley Daniels, Ph.D. (Lehigh); George A. Dinsmore, M.S. (Colorado); George C. Driscoll, Ph.D. (Lehigh); Hsai-Yang Fang, Ph.D. (West Virginia); John W. Fisher, Ph.D. (Lehigh), director NSF-ERC Advanced Technology for Large Structural Systems; Ti Huang, Ph.D. (Michigan); Robert L. Johnson, Ph.D. (Iowa State); Celal N. Kostem, Ph.D. (Arizona); Le-Wu Lu, Ph.D. (Lehigh); Alexis Ostapenko, Sc.D. (M.I.T.); Roger G. Slutter, Ph.D. (Lehigh); Robert M. Sorensen, Ph.D. (Berkeley); David A. VanHorn, Ph.D. (Iowa State); Ben-Tseng Yen, Ph.D. (Lehigh).
Associate professors. Gerard P. Lennon, Ph.D. (Cornell); Peter Mueller, Dr. sc. techn. (ETH, Zurich); Richard N. Weisman, Ph.D. (Cornell); John L. Wilson, Ph.D. (Pittsburgh).
Assistant professor. Sibel Pamukcu; Ph.D. (L.S.U.); Arup K. Sengupta, Ph.D. (Houston).

Civil engineering occupies a prominent position as one of the major fields in the engineering profession. Civil engineers are concerned with all aspects of the conception, planning, design, construction, operation, and maintenance of major physical works and facilities that are essential to modern life. Civil engineering projects are typically characterized by extreme size, complexity, durability, and cost. Examples include bridges, buildings, transportation facilities, tunnels, coastal facilities, dams, foundations, waterways, sewerage and sewage treatment facilities, and water supply and purification systems.

The undergraduate program includes a strong base of mathematics and the physical sciences, followed by a broad range of courses in the areas of engineering science and civil engineering analysis and design. In civil engineering, the courses extend across the areas of structural, geotechnical, hydraulic, environmental, and transportation engineering, along with planning, economics, probability and statistics, and surveying and measurements. The program is enriched with a series of required and elective courses in the humanities and social sciences. In addition, there are a number of elective opportunities to enable students to pursue areas of particular interest. Over the entire curriculum, emphasis is placed on the

development of a solid knowledge of civil engineering fundamentals. Concomitantly, the program is threaded with instruction and opportunities in utilizing the computer, including computer graphics, throughout the field of civil engineering.

The civil engineering program prepares individuals for entry into the engineering profession or for entry into high quality programs of graduate study. With proper selection of electives, students may also prepare for entrance into schools of law or medicine, or into master's-level programs in engineering management or business administration.

For students interested in geological engineering, a five-year program is available, leading to two bachelor of science degrees, in civil engineering and in geological sciences. The program is outlined on page 106.

Recommended Sequence of Courses

freshman engineering year (see page 36)

sophomore year, first semester (18 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Geol 101	Geology for Engineers (3)
Mech 1	Statics (3)
CE 112	Surveying (4)
Eco 1	Economics (4)

sophomore year, second semester (17 credit hours)

Math 205	Linear Methods (3)
Mech 11	Mechanics of Materials (3)
Mech 102	Dynamics (3)
CE 11	Engineering Graphics (2)
CE 17	Introduction to Computer Graphics (1)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)

junior year, first semester (18 credit hours)

CE 115	Probability and Statistics in Civil Engineering (2)
CE 117	Numerical Methods in Civil Engineering (2)
CE 121	Mechanics of Fluids (3)
CE 143	Soil Mechanics (4)
CE 159	Structural Analysis I (4)
	general studies elective (3)

junior year, second semester (17 credit hours)

CE 160	Structural Design (4)
CE 222	Hydraulic Engineering (4)
CE 270	Water Supply and Wastewater Management (3)
Mat 92	Structure and Properties of Materials (3)
	general studies or approved elective (3)

summer

CE 100	Summer Employment (0)

senior year, first semester (18 credit hours)

CE 203	Professional Development (3)
CE 213	Engineering Economics (1)
CE 217	Computer Graphics in Civil Engineering (2)
	general studies elective (3)
	approved elective(s) (6)
	free elective (3)*

senior year, second semester (18 credit hours)

CE 207	Transportation Engineering (3)
CE 214	Engineering Planning (3)
	general studies elective (3)
	general studies or approved elective (3)
	approved elective (3)
	free elective (3)*

Elective opportunities total 30 credit hours. The selection of elective courses is to be in consultation with student's academic adviser in the department of civil engineering. A total of 136 credit hours is required for the degree in civil engineering.

* Please refer to description of normal program, page 37.

Undergraduate Courses

11. Engineering Graphics (2) spring
Use of drawing instruments; freehand, lettering and shape description; theory of orthographic projection, revolution, and pictorial representation; theoretical problems in space relationships between points, lines and planes; surfaces as loci. Emphasis on visualization and geometric logic. Dinsmore

17. Introduction to Computer Graphics (1) spring
An overview of graphics systems; development of models; interactive input techniques; analyses of computer models and their results; general aspects of application programs; emphasis on typical Civil Engineering problems. No previous experience in interactive graphics is required. Prerequisites: Engineering 1; CE 11, concurrently or previously. Wilson

100. Summer Employment (0)
During the summer preceding the senior fall semester, which includes CE 203, students spend at least eight weeks in practical work, preferably in the field that the individual plans to enter after graduation. A letter from the employer confirming the dates of employment is required. Prerequisite: senior standing.

104. Readings in Civil Engineering (1-3)
Study of selected technical papers, with abstracts and reports. May be repeated for credit. Prerequisite: consent of the deparment chairperson.

112. Surveying (4) fall
Principles of plane surveying theory and practice applicable to land, engineering, topographic, and control surveys, including the influence of systematic and random errors in field and office measurements, calculations, drawings, and maps. Use of field and office equipment. Field astronomy. Horizontal, vertical, and spiral curves. Prerequisite: Math 21 previously or concurrently or consent of the department chairman. Slutter

115. Probability and Statistics in Civil Engineering (2) fall
Basic concepts of probability; probability distributions; estimation of parameters; regression and correlation. Emphasis on applications to civil engineering problems; structural reliability, random loading, traffic flow and control, and water-resource problems. Prerequisites: Math 23; Mech 11, previously or concurrently.

117. Numerical Methods in Civil Engineering (2) fall
Techniques for computer solution of linear and non-linear simultaneous equations; eigenvalue analysis; finite differences; numerical integration; numerical solutions to ordinary differential equations. Case studies in the various branches of Civil Engineering. Prerequisites: Engineering 1, Math 205. Wilson, Kostem

121. Mechanics of Fluids (3) fall, spring
Fluid properties and statics; concepts and basic equations for fluid dynamics. Forces caused by flowing fluids and energy required to transport fluids. Dynamics similitude and modeling of fluid flows. Includes laboratory experiments to demonstrate basic concepts. Prerequisite: Mech 1.

140. Special Topics in Surveying (3) spring
Geodetic coordinates, map projections, triangulation, photogrammetry, construction surveys, hydrographic surveys, underground surveys, adjustment of horizontal and vertical control nets, precise leveling, doppler satellite surveys, and aerial pollution control surveys. Field and office work. Prerequisite: CE 41. Limited enrollment. Slutter

143. Soil Mechanics (4) fall
Fundamental physical, chemical and mechanical properties affecting the engineering behavior of soils. Identification;

classification; permeability; effective stress and pore water pressures; compaction, compression and consolidation; stress-strain behavior and shear strength; laboratory tests for engineering properties; application of theories and principles in engineering practice. Prerequisite: Mech 11 or consent of the department chairperson.

158. Structural Laboratory (2) spring
Study of behavior of simple structural members. Planning, testing, and reporting. Acquisition, analysis, and presentation of experimental data. Steel, reinforced concrete, and other materials. Prerequisites: CE 160 and Met 92, previously or concurrently. Huang

159. Structural Analysis I (4) fall
Elastic analysis of statically determinate frames and trusses; deflections by the method of virtual work and moment area; force method analysis of indeterminate structures; moment distribution concept. Prerequisite: Mech 11. Dinsmore, Driscoll

160. Structural Design (4) spring
Principles of structural design. Safety and economy. Strength, stability and serviceability criteria. Selection of simple structural members to resist tensile, compressive, bending, and shearing loads. Various structural materials will be covered, especially steel and reinforced concrete. Prerequisite: CE 159. Huang, Lu

172. Fundamentals of Environmental Pollution (3) fall
Introduction to water, air, noise, solid waste, radiation and hazardous substance pollution problems. Regulatory standards and rationale, risk and hazardous assessment, economic consequences, technology for control. Prerequisite: Chem 21. Kugelman

203. Professional Development (3) fall
Elements of professionalism; professional ethics; engineering registration; continuing education; responsibilities of an engineer in industry, government, private practice; role of professional and technical societies. Prerequisite: consent of the department chairperson. Johnson

205. Design Problems (1-6)
Supervised individual design problems, with report. Prerequisite: consent of the department chairperson.

207. Transportation Engineering (3) spring
Principles of the design of transportation facilities with emphasis on highways and airports in the areas of geometric, drainage, and pavement design. Design problems. Prerequisites: CE 112 and senior standing. Slutter

211. Research Problems (1-6)
Supervised individual research problems, with report. Prerequisite: consent of the department chairperson.

213. Engineering Economics (1) fall
Financial decision-making with respect to civil engineering projects. Present value and discounted cash flow analysis, incremental analysis, and various rate of return criteria. Capital rationing among competing projects. Impact of tax provisions and inflation. Dinsmore

214. Engineering Planning (3) spring
The planning and management of civil engineering projects, including technical, economic, social, and environmental factors. Modeling and optimization methods. Decision-making criteria. Evaluation of alternatives. Prerequisite: CE 213. Dinsmore

217. Computer Graphics in Civil Engineering (2) fall
Data representation techniques; graphical standards; two and three dimensional modeling; user interfaces; input/output devices; analysis/design programs; use of modern interactive analysis programs. Prerequisites: CE 17, CE 117. Wilson

222. Hydraulic Engineering (4) spring
Flow measurements, pipe hydraulics, open-channel flow and river engineering, hydraulic structures and model studies. Laboratory experiments in applied hydraulics. Prerequisite: CE 121.

244. Foundation Engineering (3) spring
Application of the theories and principles of soil mechanics to foundation design. Site investigations and engineering tests to evaluate subsoil conditions. Bearing capacity and settlement analyses for building foundations. Lateral loads on retaining walls and bulkheads. Prerequisite: CE 143 or consent of the department chairperson. Fang

259. Structural Analysis II (3) spring
Analysis of statically indeterminate structures, methods of slope deflection and moment distribution; consideration of side-sway and nonprismatic members. Influence lines for determinate and indeteminate structures. Flexibility and stiffness matrix methods for computerized analysis. Use of computer library programs. Prerequisite: CE 159. Ostapenko

261. Structural Steel Design (3) fall
Design of steel structures, including plate girders, other built-up members, trusses, frames, grillages, shell-type structures and thin-gage members. Additional topics include connections, composite beams, and fatigue and fracture concepts related to structural design. Prerequisite: CE 160. Ostapenko or Yen

263. Structural Concrete Design (3) fall
Design of reinforced concrete structural members and simple systems, including continuous beams, columns, frames, one-and two-way slabs, and footings. Deflection, cracking, and column slenderness. Introduction to prestressing and torsion. Prerequisite: CE 160. Huang

270. Water Supply and Wastewater Management (3) spring
Quantitative analysis of water sources. Analysis and design of systems for collection, storage, transport and distribution of water for collection, and management of wastewater and storm water. Demonstration of, and field trips to water and wastewater purification facilities. Prerequisite: Chem 21 and CE 121. Johnson

280. Internship (3)
Individual opportunities for qualified advanced civil engineering students to obtain practical experience through association with civil engineers, architects and planners. Typical fields of pracitice include transportation, hydraulic engineering, environmental engineering, air pollution, regional and city planning, architectural planning, and public works engineering. A report is required. Prerequisite: senior standing. May be repeated once for credit.

309. Computer Programming (2) fall
Advanced concepts of Fortran programming in analysis and design. Emphasis on logical program requirements for proper and efficient execution. Addressing and dynamic core allocation. Use of compiler maps and loader maps. Creation and use of permanent files, magnetic tape, and update files. Prerequisite: consent of the department chairperson. Kostem

316. Civil Engineering Planning (3)
Project-oriented planning of one or two civil engineering projects of student's choice, with oral and written report; task force approach, collection and analysis of data; consideration of technical and environmental factor; cost analyses. Interaction with consulting engineers and planners. Prerequisite: senior standing or consent of the department chairperson.

322. Hydromechanics (3)
Ideal fluid flow, vortex flow, creeping motion; laminar boundary layers, turbulent shearing stress and turbulent boundary layers; turbulent jets and diffusion. Prerequisites: Math 205 and CE 222.

324. (Mech 323) Fluid Mechanics of the Ocean and Atmosphere (3)
Hydrostatics of the ocean and atmosphere. Vertical stability. Fluid motion in a rotating coordinate system. Geostrophic flow; ocean currents; surface and internal waves. Prerequisite: ME 231 or CE 121.

325. Engineering Hydrology (3) fall
Elements of the hydrologic cycle; precipitation, streamflow, evaporation, subsurface water, etc. Flood analysis, hydrographs, flood wave routing. Probability in hydrologic modeling. Hydrology in water resources engineering. Prerequisite: CE 222. Weisman

326. Ground Water Hydrology (3) spring
The study of subsurface water, its environment and distribution. Theory of ground water movement, Mechanics of well flow. Sea water intrusion, artificial recharge, basin development. Prerequisite: CE 222.

328. Open Channel Hydraulics (3) fall
Energy and momentum concepts, frictional resistance. Rapidly varied flow, gradually varied flow, river controls and channel structures. Prerequisite: CE 222.

335. Coastal Engineering (3) fall
Linear wave theory and wave characteristics; survey of non-linear theories; tides, tsunamis, storm surge and basin resonance; wind-generated wave spectra, statistics and forecasting; wave-structure interaction; nearshore circulation and sediment transport; interaction of littoral processes with structures. Prerequisite: CE 121. Sorensen

336. Harbor and Coastal Engineering Design (3) spring
Functional and structural design of breakwaters; groins, revetments and other coastal structures; shoreline stabilization; harbor entrance navigation, hydraulics, and stabilization; layout of harbors and marinas; dredging and sediment bypassing; design of marine outfalls and intakes. Prerequisite: CE 335. Sorensen

341. Ground Improvement Engineering (3) spring
The mechanisms of soil stabilization; principles and techniques; grouting and injection methods; reinforced earth methods, dynamic consolidation; deep compaction; sand drains; laboratory and field studies. Prerequisite: CE 143 or equivalent. Fang

342. Experimental Geotechnical Engineering (3) fall
Experimental studies dealing with the measurement of soil properties in the laboratory and *in situ*; application of these properties to design; consolidation; strength of soils in triaxial compression, tensile strength, and other shear tests, including measurement of pore water pressures; model design and analysis; dynamic tests; field measurement of *in situ* soil properties; laboratory and field instrumentation. Prerequisites: CE 143 and senior standing. Fang

343. Seepage and Earth Structures (3) spring
Long-and short-term stability of embankments and cut slopes; numerical and graphical methods of stability analysis; seepage through soil; design of earth dams, embankments and excavations; influence of embankment stability; construction control, field measurement of pore pressures and earth movements; model studies. Prerequisite: CE 143 or equivalent. Fang

352. Structural Dynamics (3)
Analysis of linear structural systems to time-dependent loads. Free and forced vibration. Classical and numerical methods of solution. Lumped-mass techniques, energy methods, and introduction to matrix formulation of dynamic problems. Application to design. Prerequisites: Math 205, CE 159, and Mech 102. Yen

359. Plastic Analysis and Design (3) spring
Plastic analysis and design of steel structures. Strength and behavior of frames and component parts beyond the elastic limit. Methods of predicting strength and deformation in the plastic range. Studies of industrial and multistory frames. Comparison of plastic design techniques with allowable-stress design methods. Current research. Prerequisite: CE 259 or consent of the department chairperson.

360. Structural Design Projects (3) spring
Design team approach to the analysis and design of bridges in steel and reinforced concrete, including truss, cable-stayed, arch and suspension bridges. Emphasis on the total design concept, including foundations, substructure and superstructure, with consideration of economy, strength, and performance. Prerequisites: CE 261 and CE 263. Daniels

365. Prestressed Concrete (3) spring
Principles of prestressing. Analysis and design of basic flexural members. Instantaneous and time-dependent properties of materials. Prestress losses. Additional topics may include continuity, partial prestressing, compression members, circular prestressing, etc. Prerequisite: CE 263 or consent of the department chairperson. Mueller

370. Water and Wastewater Treatment (3)
Unit operations and processes in water and wastewater treatment, sedimentation, coagulation, flocculation, filtration, disinfection, chemical treatment, ion exchange, adsorbtion, biological oxidation, sludge dewatering and stabilization. Kinetics, reactor theory, mass balances, application of fundamental physical, chemical and biological principles to analysis and design. Prerequisite: CE 270 or equivalent. Kugelman, Johnson

374. Environmental Chemistry I (3)
Chemical principles and applications of those principles to the analysis and understanding of aqueous environmental chemistry in natural waters and wastewaters. The chemistry of ionic equilibria, redox reactions, precipitation/dissolution, acid-base concepts, buffer capacity, complexation, hydrolysis and biological reactions. Three to four laboratory experiments. Prerequisite: Chem 31 or equivalent, or CE 270. Sengupta

375. Environmental Engineering Laboratory (3)
Application of laboratory based techniques to solution of environmental engineering problems. Chemical and microbiological analysis for key pollution parameters. Use of small pilot and bench scale equipment to generate design parameters. Illustration of techniques for scale-up using parameter values generated in laboratory. Practice in use of automated instrumentation for analysis. Prerequisite: CE 370, previously or concurrently. Sengupta, Kugelman

378. Water Resources Engineering Design (3) spring
Project-oriented design utilizing principles of hydraulics, hydrology and environmental engineering. Course will include lectures on selected water resource engineering topics and a design project. Prerequisites: CE 270 and CE 222. Staff

380. Design Projects (1-6) fall-spring
Design project work as a member of a team, probably including students from differing disciplines. The project attacks a situation that, when possible, relates to a problem of one of the local communities or industries. Specific projects are normally guided by faculty from several departments with consultants from off-campus. May be repeated for credit. Prerequisite: consent of the department chairperson.

381. Special Topics (1-3)
A study of selected topics in civil engineering, not included in other formal courses. Prerequisite: consent of the department chairperson.

385. Research Procedures Seminar (1) fall
Planning and execution of research projects, survey of current research, elements of proposals and budgets. Literature search procedures. Presentation of data, and of written and oral reports. Guidelined for visual aids. Beedle

Graduate Programs

Graduate studies in civil engineering enable the student to build upon the broad background of undergraduate education in preparation for professional practice at an advanced level, for research and development, or for teaching.

The selection of graduate courses and research opportunities offered in the department permits the development of individual program objectives that may be concentrated in one of the technical specialty areas, or, alternatively, may extend over the broad field of civil engineering. The department offers advanced work in the specialty areas of structural engineering, geotechnical engineering, hydraulic engineering, hydrology, coastal engineering, and environmental engineering, leading to the degrees of master of science, master of engineering, and doctor of philosophy.

A graduate program leading to the M.S. normally is concentrated in one, or possibly two, of the technical specialty areas, and consists of a number of courses designed to fulfill the individual student's program objectives. Each candidate for the M.S. is required to submit a thesis representing three to six credit hours (CE 491, listed below), or alternatively, a report based on a research course of at least three credits (CE 429, 439, 449, 469, 479, or 481). The balance of the program will consist of courses in the specialty area(s).

A graduate program leading to the M.Eng. degree stresses engineering applications and design. The courses may extend across the various specialty areas in civil engineering. Each candidate for the M.Eng. is required to complete an individual engineering project representing three to six credits in place of the thesis or research report required for the M.S.

The doctoral program, which leads to the Ph.D., normally includes courses in the major field, courses in minor fields, and a dissertation presenting results of original research. In addition, each candidate is required to have some education in one or two non-engineering fields. This requirement may be met by taking two courses (200 level or above), or by taking two foreign language courses, or by passing a foreign language proficiency examination. Holders of master's degrees planning to become candidates for the Ph.D. take a qualifying examination at the first opportunity following one semester in residence. After qualification, the program of work is formulated by the candidate, the candidate's departmental Ph.D. committee, and the department chairperson.

The laboratories of the department are located in the Fritz Engineering Laboratory. The laboratory offers outstanding facilities for research and instruction in structural engineering, geotechnical engineering, hydraulic engineering, hydrology, coastal engineering, environmental engineering, and related fields. In particular, the structural testing equipment includes dynamic testing machines, a five-million-pound universal hydraulic testing machine, and other special loading apparatus. Included in the latter are the facilities of the NSF-ERC ATLSS center located on the mountain top section of the campus. These include the largest 3-dimensional test bed in the U.S.A. and specialized earthquake testing facilities. The recently expanded hydraulic facilities include a wave tank, several flumes, a 10 cfs recirculating flow system, and two multipurpose tanks for model studies. An interdisciplinary relationship with the Center for Marine and Environmental Studies facilitates the development of research programs in environmental engineering. Brochures describing the research facilities and programs are available on request.

In addition to departmental courses, a number of courses offered by the departments of mechanical engineering and mechanics, chemistry, chemical engineering, materials science and engineering, geological sciences, and biology may also be considered a part of the major field in civil engineering. A list of such courses is available through the department chairperson.

A number of research assistantships and teaching assistantships are available to provide financial aid to students of outstanding promise. The half-time research or teaching activities required of holders of assistantships provide a valuable educational experience that supplements the formal course offerings. The graduate course offerings of the department are programmed to fit the schedule of half-time assistants, and to accommodate part-time students. A very limited number of scholarships and fellowships are available to provide financial aid for full-time study.

Graduate Courses in Civil Engineering

403. Analytical Methods in Civil Engineering (3) fall
Analytical and numerical methods used in various fields of civil engineering. Matrix algebra in engineering analysis. Iterative, differencing, and discretization techniques, energy principles and special methods. Treatment of tyical differential equations in civil engineering. Introduction to theory of elasticity with some engineering applications. Prerequisite: Math 205 or equivalent. Ostapenko

408. Computer Methods in Civil Engineering (3)
Numerical and computer-oriented methods specially applicable to the solution of complex problems arising in various fields of civil engineering. Solutions of well-and ill-conditioned linear and nolinear systems. Eigenvalue formulation of stability and dynamic problems. Reduction techniques, integration schemes for large structural systems. Optimal design by linear programming. Introduction to problem-oriented languages and computerized design. Prerequisites: CE 403 or equivalent, and working knowledge of Fortran 77 programming. Kostem or Wilson

409. Finite Element Method in Structural Mechanics (3)
spring
Basic principles and equations governing the finite element method. Analysis of planar, axisymmetric, plate and articulated structures, with emphasis on analytical modeling. Accuracy and convergence studies, utilizing different discretizations and various types of elements. Case studies include application and extension to material nonlinearities, bridges, containment vessels, and soil-structure interaction. Prerequisites: CE 403 or equivalent; working knowledge of Fortran. Kostem

424. Surface Water Hydrology (3) spring
The study of quantities in the flow of water in streams. Hydrographs. Application of statisical analysis and probability to hydrological problems. Drainage basin analysis. Prerequisite: CE 325 or equivalent.

425. Hydraulics of Sediment Transport (3)
Hydrodynamic forces on particles, settling velocity. Sediment transport in open channel: tractive force theory, bed load and suspension theory, total load and wash load. Bedform mechanics, cohesive channel hydraulics. Sediment transport in closed conduits. Shore processes and coastline hydraulics. Prerequisites: CE 121 and CE 222, and consent of the department chairperson.

426. Free Surface Flow (3)
Hydrodynamics of free surface flow phenomena; especially unsteady and spatially varied flow in open channels, and linear and higher order gravity wave theory. Derivation of basic flow equations; presentation of solution techniques and applications to rivers, estuaries and oceans. Prerequisite: consent of instructor. Sorensen and Weisman

427. Groundwater Dispersion and Diffusion (3)
Groundwater flow, transport and dispersion of contaminants in the groundwater system; groundwater chemistry including ion exchange, carbonate equilibrium, and biological reactions. Computer-based state-of-the-art groundwater contaminant transport models will be used. Selected case studies will be analyzed. Prerequisite: CE 326. Lennon

428. Advanced Topics in Hydraulics (1-3)
Recent developments in hydromechanics and hydraulics. Topics to be selected from: wave mechanics, theory of flow through porous media, dispersion, hydrodynamic forces on structures, potential flow, free streamline theory, open channel hydraulics, computer methods. Prerequisites: CE 322 and consent of the department chairperson. May be repeated for credit.

429. Hydraulic Research (1-6)
Individual research problems with reports. May be repeated for credit.

436. Advanced Topics in Coastal Engineering (1-3)
Advanced study of selected topics in coastal engineering such as: non-linear wave theory, design of coastal structures, shore protection and stabilization, numerical solution of coastal hydrodynamics. Selection of topics will depend on particular qualifications of staff, as well as on the interests of the students. Prerequisite: CE 335. May be repeated for credit.

439. Coastal Engineering Research (1-6)
Individual research problems with reports. May be repeated for credit.

443. Advanced Soil Mechanics I (3) fall
The origin, composition, and physico-chemical properties of soils and their influence on the engineering properties and behavior of soils; transmission of water in saturated and unsaturated soils; advanced theory of compaction; compression and consolidation; theories of shear strength. Prerequisite: a course in soil mechanics.

444. Advanced Soil Mechanics II (3) spring
Fundamental and advanced theories of soil mechanics applicable to earth structures and foundation design; stresses in homogeneous and layered systems for ideal elastic, plastic and visco-elastic soils; lateral earth pressures, thermo-geotechnics. Prerequisite: CE 443.

445. Advanced Foundation Engineering (3) fall
Current theory and practice relating to the design of foundations for buildings and other structures. Analysis and limitation of settlements; bearing capacity analyses of shallow and deep forndations; flexible and rigid retaining structure design; dynamic effects; anchor and other special foundations; site investigations. Prerequisite: a course in soil mechanics. Fang

447. Advanced Topics in Geotechnical Engineering (1-3)
Advanced studies in selected subjects related to geotechnical engineering. The general areas may include: stress-strain-time relationships of soils, colloidal phenomena in soils, ground water flow and seepage, soil dynamics, soil plasticity, numerial methods applied to soil mechanics, earth dam design, theories of layered systems and their application to pavement design, rock mechanics. The studies specifically undertaken in any particular semester depend on the availability of staff and the interest of students. Prerequisite: consent of the department chairperson. May be repeated for credit.

449. Geotechnical Research (1-6)
Individual research problems relating to soil engineering, with report. Prerequisite: a course in soil mechanics.

450. Advanced Structural Theory I (3) spring
Statical and geometrical stability and degree of statical indeterminacy. Application of energy methods such as virtual work, minimum total potential, minimum complementary energy, and Castigliano's theorems. Introduction to force and displacement matrix analysis of structures. Daniels

451. Advanced Structural Theory II (3) fall
Specialized methods of analysis: column analogy moment distribution. General treatment of deformation methods using matrix algebra. Selected topics in structural theory: influence lines, multi-story building frames, space structures. Introduction to finite element method; nonlinear problems. Prerequisite: CE 450. Driscoll

453. Structural Members and Frames (3) fall
General torsion of thin-walled open, closed, and combined open and closed cross-sections; general instability of thin-walled members; inelastic instability; special problems in stability. Desirable preparation: Mech 415. Prerequisites: CE 403 and consent of the department chairperson. Lu

454. Plate and Shell Structures (3)
Plates and slabs loaded transversely in their plane. Buckling and postbuckling behavior of elastic and inelastic plates. Membrane and bending analysis of cylindrical, rotational, and hyperbolic-paraboloidal shells. Emphasis on engineering methods. Design considerations. Prerequisites: CE 403 and consent of the department chairperson. Ostapenko

455. Advanced Structural Dynamics (3)
Analysis and design of structures to resist wind, earthquake, and blast loading. Matrix methods and computer applications. Non-linear and elasto-plastic response. Damping characteristics of structures and structural components, spectral analysis, dynamic instability. Characteristics of aerodynamic and seismic forces and nuclear blast. Introduction to vibration of three-dimensional structural systems. Prerequisites: CE 403, CE 352 or Mech 406, and CE 450 or equivalent. Kostem

457. Theory and Design of Steel Structures (3)
Analysis and design of steel structures; structural connections; composite steel-concrete systems and other components. Consideration of residual stress; brittle fracture; fatigue strength; fastener systems. Study of current research and application to design practice. Fisher

459. Advanced Topics in Plastic Theory (3) fall
Fundamentals of the mathematical theory of plasticity; the general theorems of limit analysis and their applications to beams under combined loading, arches, space frames, plates and shells. Limit analysis of two-and three-dimensional problems in soil, concrete, rock, and metal. Current developments. Prerequisite: CE 359.

460. Civil Engineering Project (1-6)
An intensive study of one or more areas of civil engineering, with emphasis on engineering design and applications. A written report is required. May be repeated for credit.

462. Experimental Methods of Structural Analysis (3)
Analysis of structures using experimental techniques; use of mechanical devices in study of temperature deformations, foundation displacements, and integral action of structures; moire fringe method; theory of similitude with application to model design; structural analogies.

463. Experimental Methods of Structural Research (3)
Mechanical properties of structural materials and different procedures of evaluating these properties; experimental methods of stress analysis; statistical analysis of experimental data.

464. (Mech 416) Analysis of Plates and Shells (3)
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of in-plane forces, large deflections, buckling of plates. Geometry and governing equations of shells, shells of revolution, membrane states, edge solutions, solution by numerical integration, nonsymmetric problems, buckling of shells, applications to pressure vessels. Prerequisites: Math 205; Mech 305, or equivalent course in advanced mechanics of materials. Kalnins or Updike

465. Advanced Topics in Concrete Structures (3) fall
Advanced topics in reinforced concrete with or without prestress. Analysis and design for torsion. Limit design concepts. Design of slab systems: strength design method, yield line theory and strip method. Other topics may include composite members, probabilistic basis of design codes, and building and bridge design. Prerequisites: CE 263 and CE 365 or equivalent, or consent of department chairperson. Huang

466. Concrete Shell Structures (3)
Analysis and design of concrete shell structures. Folded plates, cylindrical shells, and shells of double curvature. Typical practical problems. Prerequisites: CE 403 and consent of the department chairperson. Ostapenko

467. Advanced Topics in Structural Engineering (1-3)
Advanced study of selected topics in structural mechanics and engineering, such as: finite element methods, suspension system; space frames; stability of nonlinear systems; coldformed and lightweight construction; optimization and reliability; second-order phenomena in structures; interaction of structures with the environment; structural use of plastics; composite construction, etc. Selection of topics will depend on particular qualifications of the staff, as well as on the interests of the students. Prerequisite: consent of the department chairperson. May be repeated for credit.

468. (Mech 415) Stability of Elastic Structures (3)
Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilever column. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Buckling by torsion and flexure. Variational methods. Buckling of frames. Instability problems of thin plates and shells. Prerequisite: Math 205. Kalnins

469. Structural Research (1-6)
Individual research with reports. May be repeated for credit.

471. Water Treatment Facilities (3) fall
Theory and design of water treatment facility components, from source to distribution system. Laboratory work in water chemical parameter determinations for design applications. Prerequisite: CE 374. Johnson or Kugelman

472. Water Pollution Control Facilities (3) spring
Fundamental principles and design of water pollution control facilities for domestic and industrial waste water. Physical-chemical and biological studies in laboratory determination of design parameters to be applied in design procedures. Prerequisite: CE 374. Johnson or Kugelman

475. Advanced Topics in Water Resources (1-3)
Advanced study of selected topics in areas such as: physicochemical methods of water quality control; biological systems for waste-water treatment; multiple use of water resources; and others. Selection of topics will depend on particular qualifications of the faculty as well as interest of the students. Prerequisite: consent of the department chairperson. May be repeated for credit.

479. Environmental Engineering Research (1-6)
Individual research problems in environmental engineering with report. May be repeated for credit.

481. Special Problems (1-6)
An intensive study, with report, of a special field of civil engineering which is not covered in the other courses. A design project or an interdisciplinary study of a problem related to civil engineering may also be included. May be repeated for credit.

483. Graduate Seminar (1-3)
Study of current topics in civil engineering.

491. Thesis (1-6)

499. Dissertation (1-15)

Civil Engineering and Geological Sciences

This program is designed for students interested in geological engineering, and leads to two bachelor of science degrees, in civil engineering and in geological sciences, both awarded at the end of the fifth year. The total number of credits in the program is 183, including two summer camps which comprise nine credits.

The program provides alternatives for students who may decide not to complete the two-degree program. Students who make this decision prior to the beginning of the fourth year may qualify at the end of that year for the bachelor of science in civil engineering, as well as a minor in geological sciences. On the other hand, if a student decides after two years to pursue only the bachelor of science in geological sciences, it is possible to complete the requirements in four years. If the decision to work toward this degree is made during the fourth year, at least one additional semester is required to qualify for either bachelor degree. Interested students should consult with the undergraduate officer in the department of civil engineering.

freshman engineering year (see page 36)

second year, first semester (17 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Mech 1	Statics (3)
Chem 31	Chemical Equilibria in Aqueous Systems (3)
Geol 101	Geology for Engineers (3)
CE 112	Surveying (4)

second year, second semester (17 credit hours)

Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Mech 11	Mechanics of Materials (3)
Geol 31	Historical Geology and Stratigraphy (3)
Mech 102	Dynamics (3)
CE 11	Engineering Graphics (2)
CE 17	Introduction to Computer Graphics (1)

third year, first semester (18 credit hours)

Math 205	Linear Methods (3)
CE 115	Probability and Statistics in Civil Engineering (2)
CE 121	Mechanics of Fluids (3)
CE 143	Soil Mechanics (4)
Geol 123	Structural Geology (3)
Geol 133	Introductory Mineralogy and Petrology (3)

third year, second semester (17 credit hours)

Mat 92	Structure and Properties of Materials (3)
CE 222	Hydraulic Engineering (4)
CE 270	Water Supply and Wastewater Management (3)
Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Geol 346	Case Histories in Engineering Geology (3)

summer

CE 100	Summer Employment (0)†

fourth year, first semester (18 credit hours)

CE 117	Numerical Methods in Civil Engineering (2)
CE 159	Structural Analysis I (4)
Geol 301	Introduction to Geophysics (3)
Geol 313	Sedimentology (3)
Geol 333	Crystallography (3)
Geol 356	Ground Water (3)

fourth year, second semester (18 credit hours)

CE 160	Structural Design (4)
Geol 312	Geomorphology (3)
Geol 334	Petrology and Petrography (4)
Eco 1	Economics (4)
elective	humanities and social sciences (3)

summer (6 credit hours)

Geol 341	Field Geology (6)

fifth year, first semester (18 credit hours)

CE 203	Professional Development (3)
CE 213	Engineering Economics (1)
CE 217	Computer Graphics in Civil Engineering (2)
elective	Geology (3)
electives	humanities and social sciences (6)
elective	approved elective (3)*

fifth year, second semester (18 credit hours)

CE 207	Transportation Engineering (3)
CE 214	Engineering Planning (3)
elective	Civil Engineering (3)
elective	Geology (3)
electives	humanities and social sciences (6)

†Eight weeks of summer employment should precede the fourth year. Consult the civil engineering department chairperson.

*Elective that requires approval of the civil engineering department chairperson.

Classics

Associate professors. Charles Robert Phillips, III, Ph.D. (Brown), *chairperson;* Amy E. Richlin, Ph.D. (Yale).
Assistant professor. Julie A. Williams, Ph.D. (Cambridge).

The study of classics examines firstly the origins and growth of Greek and Roman culture in the Mediterranean area and secondly its impact on that area (and others) until the present. This study is by nature interdisciplinary: the study of language and literature, history, philosophy and religion, archaeology, economics and science all contribute to an appreciation of Greco-Roman civilization.

Students in either major or minor programs may concentrate in various combinations of these and other disciplines as they relate to ancient civilization. The diversity of professional interest in the department should encourage the student to follow her or his special interests while simultaneously gaining an overview of classical civilization.

Courses in Ancient Greek and Latin lead to proficiency in language while introducing the student to major literary texts. The Joseph A. Maurer Classics Prize is awarded yearly, at the discretion of the department, to the senior(s) who has demonstrated outstanding achievement in Classics (Ancient Greek or Latin) and/or Classical Civilization. Courses in classical civilization require no knowledge of the ancient languages; they offer introductions to various disciplines of classics with frequent reference to modern perspectives. Upper-level courses tend to be small, fostering closeness between faculty and students.

Petitions are required for freshmen to take 100-level or higher courses and for sophomores to take 200-level or higher courses.

Major programs. Students may major either in Classical Civilization or Classics. The Classical Civilization major has no language requirement, although students are encouraged to take language courses in partial fulfillment of major requirements. The Classics major offers a comprehensive view of language and culture; it is possible to begin an ancient language at Lehigh and to complete the major program successfully. Depending on interests and preparation, the student should derive equal educational benefit from either major program. The department welcomes double majors and the educational perspectives to be derived from combining ancient and modern studies.

Classics as a major has stood the test of time, offering helpful preparation for careers in widely diverse fields in the professions, business, and public service. Lehigh classics majors have gone on to law school, the ministry, business school, with appropriate science courses to medical school, graduate work in classics, and to all kinds of entry-level employment.

Departmental Honors. A student may be recommended for Departmental Honors by vote of the department based on the student's course work and performance on the senior comprehensive examination.
Minor program. The minor in Classical Civilization or Classics consists of a minimum of fifteen credit hours. Students may focus on any aspect of classical studies, either singly or in combination. The department can arrange individual programs.
Study abroad. Lehigh University is a cooperating institution of the Intercollegiate Center for Classical Studies at Rome and of the American School of Classical Studies at Athens. Lehigh students are eligible for tuition grants at Athens and Rome.
Note: Courses designated Clss are taught in English. No knowledge of Latin or Ancient Greek is involved.

Major in Classical Civilization

This major allows the student to concentrate either in classical archaeology or classical literature while gaining an overview of Greco-Roman culture. No knowledge of ancient languages is required, although students may substitute six credit hours, with the department chairperson's consent, for required major courses. Students are encouraged to individualize their programs by means of appropriate collateral courses chosen in consultation with the department chairperson.

required preliminary courses (6 credit hours)

Clss 21	Greek History (3)
Clss 22	Roman History (3)

required major courses (24 credit hours in one of the areas of concentration)

Concentration in Archaeology

Clss 82	Art and Archaeology of Greece (3)
Clss 103	Archaeology of Italy (3)
Clss 108	Ancient Technology (3)
Clss 201	Archaeology: Lands of the Bible (3)
Clss 204	Ancient City and Society (3)
Anth 11	Sociocultural Anthropology (3) **or**
Anth 12	Emergence of Mankind and Culture (3)

one course chosen from the area of classical literature (3)
one course chosen from the following: Clss 251, Phil 131, RS 111, 114 (3)

Concentration in Classical Literature

Clss 52	Latin Literature in English Translation (3)
Clss 64	Homer to Plato: Greek Literature in Translation (3)
Clss 152	Women in Antiquity (3)
Clss 161	Roman Law (3)
Clss 251	Classical Mythology (3)

two courses chosen from the area of archaeology (6)
one course chosen from the following: Clss 213, RS 111, 114 (3)
Two courses in either Ancient Greek or Latin may be substituted (see above).

A senior comprehensive examination is required.

Major in Classics

This major allows the student to concentrate in Ancient Greek, Latin or both. Specific programs for this major are worked out for each student with due consideration for the individual's particular previous study of the language(s). Students wishing to concentrate in both languages should consult the department chairperson as soon as possible on their arrival at Lehigh. Thus a student may begin Ancient Greek or Latin at Lehigh and successfully complete a major in it. In general, the program requires as a minimum:

required preliminary courses (18 credit hours *maximum*, depending on previous language study)
Clss 21 Greek History (3)
Clss 22 Roman History (3)
either Greek 1, 2, 11, 12 or Latin 1, 2, 11, 12, or appropriate placement as determined by the department chairperson.

required major courses (30 credit hours)
twelve credit hours in advanced courses in the major language
six credit hours in the second language, taken at any level
three credit hours in archaeology
three credit hours in philosophy/religion, chosen from the following: Clss 251, Phil 131, RS 111, 114
six credit hours from either classical civilization courses or approved collateral courses.

A senior comprehensive examination is required.

Courses in Classical Civilization (Clss)

Clss 21. (Hist 21) Greek History (3) fall
The development of civilization from palaeolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic and literary development of the ancient world; the origin of political institutions. Phillips

Clss 22. (Hist 22) Roman History (3) spring
Rome from its origins to A.D. 476. Political, social and religious developments. Transformation of the late Roman Empire to the early medieval period. Phillips

Clss 51. Masterworks of Greek and Roman Theatre (3) fall
Tragedies and comedies from ancient Greece and Rome. Effects of stage conventions and social norms on actor, playwright and play; lectures; discussion.

Clss 52. Latin Literature in English Translation (3)
Readings in major genres of Latin literature. Emphasis on epic, Roman comedy, and satire. No knowledge of the Latin language is required.

Clss 64. Homer to Plato: Greek Literature in Translation (3)
Lectures and discussions on archaic and classical Greek literature, including the *Iliad*; Hesiod, *Works and Days*; Sappho, the tragic poets; Aristophanes' comedies; and Plato's *Apology* and *Symposium*.

Clss 82. (Art 82) Art and Archaeology of Greece (3)
The art and architecture of ancient Greece as revealed by archaeology. Brief surveys of the political and cultural backgrounds to the various artistic periods: Bronze Age, Geometric, Orientalizing, Classical, Hellenistic and Roman. Lectures, slides and films.

Clss 103. (Arch 103) Archaeology of Italy (3)
Neolithic, Terramaran, Villanovan and Etruscan cultures. Rome the city: its buildings, monuments and streets, through the kingdom, republic, and empire. Survey of Pompeii, Herculaneum and Ostia. Lectures, readings and reports.

Clss 108. Ancient Technology (3) spring
Technology and technique from the stone ages to the beginning of the industrial age; their effects on society. Attitudes to technology in ancient myth literature, philosophy, and religion.

Clss 131. (Phil 131) Ancient Philosophy (3) fall
Historical study of philosophy in the classical world from the pre-Socratics to Plato, Aristotle, and the Neo-Platonists, as the originators of the western tradition in philosophy and as interacting with the religious, political, and scientific life of their times. Hare

Clss 132. Medical Terminology (1-3)
Basic knowledge of Greek and Latin roots used in medical and health sciences. Rules for combining forms, for recognition of variants. Exercises in etymology.

Clss 152. Women in Antiquity (3)
Interdisciplinary study of women in Greece and Rome. Literary, archaeological and historical evidence and approaches. Cross-cultural material. Richlin

Clss 161. Roman Law (3)
Examination of Roman legal systems from the *Twelve Tables* to the *Digest* of Justinian. Emphasis on development of legal concepts and their historical context. Readings in primary sources; lectures; discussion. Phillips

Clss 201. (Art 201) Archaeology: Lands of the Bible (3)
Chronological survey of archaeological finds from Palaeolithic, Neolithic, Bronze Age, Iron Age, and late cultures in the Near East. Material illustrating the cultures and events of the Bible.

Clss 204. (Arch 204) Ancient City and Society (3)
Ancient theories of city and city planning; attitudes to life in the city; rise of urban civilization from Neolithic prototypes through the Near East, Egypt, Greece, and Rome; insights applicable to current urban problems.

Clss 213. (Rel 213) Ancient Roman Religion (3)
Religious experience of the Roman people from prehistory to end of the Empire. Nature of polytheism and its interactions with monotheism (Christianity, Judaism). Theories of religion. Emphasis on primary source materials.

Clss 215. (Hist 215) Decline and Fall of the Roman Empire (3)
Political, social, and economic history of the Roman Empire, A.D. 117-A.D. 565. Romanization of the provinces, diffusion of Christianity, and special attention to transformation to medieval period. Includes readings in translation of primary sources. Phillips

Clss 251. (Rel 251) Classical Mythology (3)
Myth, religion, and ritual in ancient Greece and Rome. Emphasis on primary sources; introduction to ancient and modern theories of religion. Cross-cultural material. Phillips

Clss 281. Readings (3) fall
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisite: Clss 21 or 22 and consent of the department chairperson.

Clss 282. Readings (3) spring
Advanced study of a historical period or theme. Emphasis on primary sources. Prerequisite: Clss 21 or 22 and consent of the department chairperson.

Courses in Ancient Greek

Grk 1. Elementary Greek (3) fall
Fundamentals of the Greek language. Readings in the easier authors.

Grk 2. Elementary Greek (3) spring
Continued work in Greek vocabulary, forms, and syntax. Selected readings in Greek. Prerequisite: Grk 1.

Grk 11. Intermediate Greek (3) fall
Readings in Herodotus, Homer, or Xenophon. Grammar review. Prerequisite: Grk 1 and 2, or one year of entrance Greek, or consent of department chairperson.

Grk 12. Intermediate Greek (3) spring
Plato: *Euthyphro, Apology* and *Crito*, or other dialogues. Prerequisite: Grk 11.

Grk 111. Greek Drama (3) fall, alternate years
Representative plays of Sophocles, Euripides and Aristophanes. Literary study of the drama. Prerequisite: Grk 12.

Grk 112. Greek Drama (3) spring, alternate years
Continuation of Gk 111. Prerequisite: Grk 12.

Grk 113. Greek Historians (3) fall, alternate years
Selections from Herodotus, Thucydides or Xenophon. Study of Greek historiography. Prerequisite: Grk 12.

Grk 271. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisite: six credit hours at the 100 level and consent of the department chairperson.

Grk 272. Readings (3) spring
Intensive readings in one author or in a selected genre. Prerequisite: six credit hours of courses at the 100 level and consent of the department chairperson.

Courses in Latin

Lat 1. Elementary Latin (4) fall
Fundamentals of grammar and syntax. Introduction to Ovid's version of Greek mythology. Emphasis on language structure and vocabulary building.

Lat 2. Elementary Latin (3) spring
Easy Latin prose and poetry. Prerequisite: Lat 1 or one to two years of entrance Latin.

Lat 11. Intermediate Latin (3) fall
Readings in Latin prose or poetry. Consolidation of reading ability; introduction to literary analysis. Prerequisite: Lat 2 or consent of department chairperson.

Lat 12. Intermediate Latin (3) spring
Readings in Latin prose or poetry. Consolidation of reading ability; introduction to literary analysis. Prerequisite: Lat 2 or consent of department chairperson.

Lat 111. Catullus and Horace (3) fall
Translation and analysis of selected lyrics, focusing on imagery systems. Introduction to metrics. Prerequisite: Lat 12 or consent of department chairperson.

Lat 112. Republican Prose: The Roman Revolution (3) spring
Letters of Cicero, the *Invectives* against Cicero and Sallust and Sallust's *Catiline*. Prerequisite: Lat 12 or consent of chairperson.

Lat 113. Vergil (3) fall
Selections from the *Aeneid*. Vergil's creation of a Latin epic and its ambiguities. Metrics. Prerequisite: Lat 12 or consent of chairperson.

Lat 114. Livy (3) spring
Selections from the early books of Livy's histories focusing on his creation of a Roman *mythos*. Style. Prerequisite: Lat 12 or consent of chairperson.

Lat 115. Ovid (3) fall
Selections from the *Ars Amatoria* and *Metamorphoses* 6-10, focusing on Ovid's problem with ideology. Metrics. Prerequisite: Lat 12 or consent of department chairperson.

Lat 116. Petronius (3) spring
Selections from the *Satyricon*, focusing on language usage and epic travesty. Prerequisite: Lat 12 or consent of chairperson.

Lat 211. Readings (3) fall
Intensive readings in one author or in a selected genre. Prerequisite: six hours of courses at the 100 level and consent of the department chairperson.

Lat 212. Readings (3) spring
Intensive reading in one author or in a selected genre. Prerequisite: six hours of courses at the 100 level and consent of the department chairperson.

Lat 303. The Roman Epic (3)
The epic in Latin literature; selections from Lucretius, Catullus and Ovid; critical study of Vergil's *Aeneid*. Prerequisite: six hours of courses at the 100 level and consent of the department chairperson.

Computer Engineering

See listings under Computer Science and Electrical Engineering.

Computer Science and Electrical Engineering

Professors. Lawrence J. Varnerin, Ph.D. (M.I.T.), *chairperson;* Donald J. Hillman, Ph.D. (Cambridge, England), *computer science division head;* Donald M. Bolle, Ph.D. (Purdue), *dean of the College of Engineering and Applied Science ;* John J. Karakash, Eng.D. (Hon.) (Lehigh), *distinguished professor emeritus and dean emeritus of the College of Engineering and Applied Science ;* Robert F. Barnes, Ph.D. (Berkeley); Walter E. Dahlke, Ph.D. (Jena, Germany), *emeritus;* D. Richard Decker, Ph.D. (Lehigh); Richard T. Denton, Ph.D. (Michigan); Nikolai Eberhardt, Ph.D. (Munich, Germany); Frank J. Feigl, Ph.D. (Pittsburgh); Bruce D. Fritchman, Ph.D. (Lehigh); Samuel L. Gulden, M.A. (Princeton); Frank H. Hielscher, Ph.D. (Illinois); Carl S. Holzinger, Ph.D. (Lehigh); Ralph J. Jaccodine, Ph.D. (Notre Dame); Arthur I. Larky, Ph.D. (Stanford); Daniel Leenov, Ph.D. (Chicago); Roger N. Nagel, Ph.D. (Maryland); John J. O'Connor, Ph.D. (Columbia); Herbert Rubenstein, Ph.D. (Columbia); William E. Schiesser, Ph.D. (Princeton); Alfred K. Susskind, S.M. (M.I.T.); Eric D. Thompson, Ph.D. (M.I.T.); Leroy J. Tuscher, Ph.D. (Florida State); Kenneth K. Tzeng, Ph.D. (Illinois); Marvin H. White, Ph.D. (Ohio State).
Associate professors. Donald L. Talhelm, M.S. (Lehigh), *electrical engineering division head;* Douglas R. Frey, Ph.D. (Lehigh); Edwin J. Kay, Ph.D. (Lehigh); Karl H. Norian, Ph.D. (Imperial College, London); Peggy A. Ota, Ph.D. (Pennsylvania); Gerhard Rayna, Ph.D. (Princeton); Meghanad D. Wagh, Ph.D. (I.I.T., Bombay).
Adjunct lecturers. Clarence Joh, Ph.D. (SUNY); H. Charles Liebold, M.S. (Lehigh).

The department of computer science and electrical engineering offers undergraduate and graduate programs of study along with supporting research for students interested in the fields of electrical engineering, computer engineering, and computer science. Lehigh University offers a bachelor of science degree from the College of Engineering and Applied Science in electrical engineering, computer engineering, and computer science, and it offers the bachelor of science and bachelor of arts degree from the College of Arts and Science in computer science. A minor in computer science is available except for students in the College of Engineering and Applied Science.

Graduate study leads to the degrees master of science, master of engineering, and doctor of philosophy in electrical engineering and to the degrees master of science and doctor of philosophy in computer science. Computer engineering graduate students elect either the electrical engineering or the computer science degree designation according to their personal dictates.

While each of the programs has its unique attributes, Lehigh's programs exploit the growing interrelationship among electrical engineering, computer engineering, and computer science. For example, a new computer system which may encompass fundamental algorithmic development, innovative architecture and logic design, and very large scale integrated circuit design and fabrication requires the expertise

of individuals knowledgeable across the spectrum. Robotics experts similarly require a broad knowledge spectrum.

The undergraduate programs emphasize the fundamental aspects of their respective areas. Electives permit the student to tailor his program according to his interests and goals, whether they be in preparation for graduate study or entry into industry. Students are free to select courses offered by other departments and are encouraged to do so when appropriate. In this way they can prepare themselves for activities which straddle departmental boundaries or for entry into professional schools such as medicine or management. Students have the opportunity to synthesize and apply their knowledge in a senior design and/or research project.

The graduate programs allow students to deepen their professional knowledge, understanding, and capability within their subspecialties. The thesis is regarded as an essential and important ingredient of these programs. Each graduate student develops a program of study in consultation with his or her graduate advisor.

Key research thrust areas in which departmental research has achieved recognition include:

1. Artificial Intelligence, particularly as applied to manufacturing.
2. Microelectronics including processing, VLSI Design and design automation.
3. Communications, including networking and computer architecture.
4. Electromagnetics including both microwaves and photonics.

Graduate research is encouraged in these areas.

The department maintains a number of laboratories in support of its curricular programs. These laboratories include the electronics circuits laboratory, the microcomputer laboratory, the electromechanics laboratory, and the digital systems laboratory as dedicated undergraduate laboratories. The department has research laboratories in artificial intelligence, computer architectures, cryogenic circuits; design and computing systems; electron device physics; microelectronics fabrication; microprocessor control for energy applications; microwave measurements; microwave monolithic circuits; robotics; and a VLSI measurements laboratory. These laboratories are described more completely in the departmental graduate brochure. These laboratories, among others, are available for undergraduate projects.

Computers and computer usage are an essential part of the student's environment. The University provides mainframe computing on its CDC CYBER 850 and DEC 2060 computers, and the department provides computing support on its Harris 800 superminicomputer, its 8 valid SCADstar integrated VLSI logic and layout design workstations, and its 60 Intel microcomputers. Students are not now required to have a personal microcomputer but some find such a tool an asset.

A detailed description of the curricular programs follows with a listing of the required courses and with a listing of the departmental course offerings. The departmental courses carry the prefixes CSc for computer science and ECE for electrical engineering. The student is urged to search in both listings for courses appropriate to his career goal.

Undergraduate Programs

Bachelor of Science in Electrical Engineering

The required courses for this degree contain the fundamentals of linear circuits, systems and control theory, electronic circuits, signal theory, physical electronics, electromagnetic theory, energy conversion, digital systems, and computing techniques. A strong foundation in the physical sciences and in mathematics is required. Approved electives, chosen with the advisor's consent, are selected in preparation for graduate study or entry into industry according to individual interests. The program totals 134 credit hours. The recommended sequence of courses follows:

freshman year (see page 36)

sophomore year, first semester (17 credit hours)

Phys 21, 22	Introductory Physics II and Laboratory II (5)
Math 23	Analytic Geometry and Calculus III (4)
ECE 81	Principles of Electrical Engineering (4)
CSc 33	Principles of Computer Engineering (4)

sophomore year, second semester (17 credit hours)

ECE 108	Signals and Systems (4)
Math 205	Linear Methods (3)
Eco 1	Economics (4)
	general studies (3)
	approved elective* (3)

junior year, first semester (17 credit hours)

ECE 121	Electronic Circuits Laboratory (2)
ECE 123	Electronic Circuits (3)
ECE 125	Circuits and Systems (3)
Math 231	Probability and Statistics (3) or
Math 309	Theory of Probability (3)
	general studies (3)
	free elective (3)

junior year, second semester (17 credit hours)

ECE 126	Physical Electronics (3)
ECE 136	Electromechanics Laboratory (3)
ECE 138	Digital Systems Laboratory (2)
ECE 202	Introduction to Electromagnetics (3)
	approved electives* (3)
	free elective (3)

senior year, first semester (18 credit hours)

ECE 111	Proseminar (1)
ECE 151	Senior Laboratory I (2)
ECE 203	Introduction to Electromagnetic Waves (3)
	general studies (3)
	approved electives* (6)
	free elective (3)

senior year, second semester (18 credit hours)

	approved electives* (12)
	general studies (3)
	free elective (3)

*Approved electives are subjects predominantly in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. Students must choose at least one elective in mathematics, at least one elective in either materials, thermodynamics, fluid mechanics or physical chemistry, and at least one elective in physics, chemistry or biology. For students interested in solid-state electronics, quantum mechanics is recommended.

Bachelor of Science in Computer Engineering

The required courses for this degree contain the fundamentals of electronic circuits, signal theory, logic design, computer architecture, structured programming, data structures, software engineering, discrete mathematics, and numerical analysis. A strong foundation in the physical sciences and in mathematics is required. Approved electives, chosen with the advisor's consent, are selected in preparation for graduate study or entry into industry according to individual interests. The program totals 135 credit hours. The recommended sequence of courses follows:

freshman year (see page 36)

sophomore year, first semester (17 credit hours)

Phys 21, 22	Introductory Physics II and Laboratory II (5)
Math 23	Analytic Geometry and Calculus III (4)
ECE 81	Principles of Electrical Engineering (4)
CSc 33	Principles of Computer Engineering (4)

sophomore year, second semester (17 credit hours)

CSc 17	Structured Programming and Data Structures (4)
ECE 108	Signals and Systems (4)
CSc 261	Discrete Structures (3)
Math 205	Linear Methods (3)
	general studies (3)

junior year, first semester (17 credit hours)

ECE 121	Electronic Circuits Laboratory (2)
ECE 123	Electronic Circuits (3)
ECE 125	Circuits and Systems (3)
Math 231	Probability and Statistics (3) **or**
Math 309	Theory of Probability (3)
	general studies (3)
	free elective (3)

junior year, second semester (18 credit hours)

ECE 116	Software Engineering (3)
ECE 138	Digital Systems Laboratory (2)
ECE 201	Computer Architecture (3)
Eco 1	Economics (4)
	approved electives* (3)
	free elective (3)

senior year, first semester (18 credit hours)

ECE 111	Proseminar (1)
ECE 151	Senior Laboratory I (2)
Math 230	Numerical Methods (3) **or**
Engr 250	Computer Modeling of Scientific and Engineering Systems (3)
	general studies (3)
	approved electives* (6)
	free elective (3)

senior year, second semester (18 credit hours)

	approved electives* (12)
	general studies (3)
	free elective (3)

*Approved electives are subjects in the area of science and technology. They are not restricted to offerings in the department of computer science and electrical engineering. One elective must be an engineering science elective from another department.

Bachelor of Science in Computer Science

This degree is available as a 122 credit hour program to students in the College of Arts and Science and as a 133 credit hour program in the College of Engineering and Applied Science. The two college programs are identical in the fundamental requirements in mathematics and computer science, and the programs are appropriate for entry into management or industrial positions and for continued graduate study. The programs differ in that the students must fulfill the distribution requirements of the respective college. Students with interests in management, finance, data processing, and information handling may find the Arts and Science College program more appropriate and students with interests in engineering and science applications may find the Engineering and Applied Science College program more appropriate.

The required courses for this degree contain the fundamentals of discrete mathematics, structured programming, algorithms, computer architectures, compiler design, operating systems, and programming languages. A strong foundation in mathematics is required. Six credit hours of computer science project are required. The recommended sequence of courses is as follows:

College of Arts and Science

freshman year, first semester (16 credit hours)

Engl 1	Composition and Literature (3)
Math 21	Analytic Geometry and Calculus I (4)
CSc 11	Introduction to Structured Programming (3) *
	distribution (6)

freshman year, second semester (17 credit hours)

Engl 2	Composition and Literature: Fiction, Drama, Poetry (3)
Math 22	Analytic Geometry and Calculus II (4)
CSc 15	Data Structures (4) *
	distribution (6)

sophomore year, first semester (17 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
CSc 33	Principles of Computer Engineering (4)
CSc 181	Advanced Programming (3)
CSc 261	Discrete Structures (3) **or**
Math 243	Algebra (3)
	distribution (3)

sophomore year, second semester (15 credit hours)

Math 205	Linear Methods (3)
CSc 211	Computer Organization (3)
	approved electives** (6)
	distribution (3)

junior year, first semester (15 credit hours)

Math 230	Numerical Methods (3)
Math 231	Probability and Statistics (3)
CSc 318	Computing Algebra (3)
	approved elective** (3)
	distribution (3)

junior year, second semester (15 credit hours)

CSc 241	Data Base Systems (3)
CSc 262	Programming Languages (3)
CSc 302	Compiler Design (3)
	approved elective** (3)
	distribution (3)

senior year, first semester (15 credit hours)

CSc 303	Operating System Design (3)
CSc 371	Readings and Project I (3)
	approved electives** (6)
	distribution (3)

senior year, second semester (12 credit hours)

CSc 372	Readings and Project II (3)
	approved electives** (6)
	distribution (3)

*With approval, CSc 17, Structured Programming and Data Structures (4), and a 3 credit hour approved elective may be substituted for CSc 11 and CSc 15.
**Approved electives are chosen by the student, with the approval of the major advisor, to support the professional objectives of the student.

College of Engineering and Applied Science

freshman year (see page 36)

sophomore year, first semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
ECE 81	Principles of Electrical Engineering (4)
CSc 17	Structured Programming and Data Structures (4)
Eco 1	Economics (4)

sophomore year, second semester (18 credit hours)

Math 205	Linear Methods (3)
CSc 181	Advanced Programming (3)
CSc 33	Principles of Computer Engineering (4)
CSc 261	Discrete Structures (3) **or**
Math 243	Algebra (3)
Phys 21, 22	Introductory Physics II and Laboratory (5)

junior year, first semester (15 credit hours)

Math 231	Probability and Statistics (3) **or**
Math 309	Theory of Probability (3)
CSc 262	Programming Languages (3)
CSc 335	Micro Processor Software Design (3)
CSc 211	Computer Organization (3)
	general studies (3)

junior year, second semester (18 credit hours)

CSc 241	Data Base Systems (3)
CSc 302	Compiler Design (3)
	general studies (3)
	approved electives** (6)
	free elective (3)

senior year, first semester (18 credit hours)

Math 230	Numerical Methods (3) **or**
Engr 250	Computer Modeling of Scientific and Engineering Systems (3)
CSc 371	Readings and Project I (3)
CSc 303	Operating System Design (3)
	general studies (3)
	approved elective** (3)
	free elective (3)

senior year, second semester (18 credit hours)

CSc 372	Readings and Project II (3)
CSc 327	Artificial Intelligence Applications (3)
	general studies (3)
	approved elective** (6)
	free elective (3)

**Approved electives are chosen by the student, with the approval of the major advisor, to support the professional objectives of the student.

Bachelor of Arts in Computer Science

This program of 121 credit hours is for students who desire a strong liberal arts program with a concentration in computer science. The program contains the fundamentals of computer science which include discrete mathematics, structured programming, data structures, programming languages, computer organization, compiler design, and operating systems. A three credit hour senior project is required. The recommended course sequence is as follows:

freshman year, first semester (16 credit hours)

Engl 1	Composition and Literature (3)
Math 21	Analytic Geometry and Calculus I (4)
CSc 11	Introduction to Structured Programming (3) *
	distribution (6)

freshman year, second semester (17 credit hours)

Engl 2	Composition and Literature: Fiction, Drama, Poetry (3)
Math 22	Analytic Geometry and Calculus II (4)
CSc 15	Data Structures (4) *
	distribution (6)

sophomore year, first semester (15-16 credit hours)

CSc 261	Discrete Structures (3) **or**
Math 243	Algebra (3)
CSc 33	Principles of Computer Engineering (4) **or**
CSc 102	Foundations of Computing Science (3)
CSc 181	Advanced Programming (3)
	distribution (6)

sophomore year, second semester (15 credit hours)

Math 43	BMSS Linear Algebra (3)
CSc 211	Computer Organization (3)
	approved elective (3)
	distribution (6)

junior year, first semester (15 credit hours)

CSc 262	Programming Languages (3)
	distribution (6)
	free electives (6)

junior year, second semester (15 credit hours)

CSc 302	Compiler Design (3)
	distribution (6)
	free electives (6)

senior year, first semester (15 credit hours)

CSc 303	Operating System Design (3)
CSc 371	Readings and Project I (3)
	distribution (3)
	free electives (6)

senior year, second semester (12 credit hours)

	distribution (3)
	free electives (9)

*With approval, CSc 17, Structured Programming and Data Structures (4), and a free elective may replace CSc 11 and CSc 15.

Minor in Computer Science

The minor in computer science provides a concentration which includes discrete mathematics, structured programming concepts, programming languages, and computer organization, essential elements of computer science. This minor is not available to students of the College of Engineering and Applied Science. The minor is as follows:

Math 21	Analytic Geometry and Calculus I (4)
CSc 261	Discrete Structures (3)
CSc 11	Introduction to Structured Programming (3) *
CSc 15	Data Structures (4) *
CSc 33	Principles of Computer Engineering (4) **or**
CSc 211	Computer Organization (3)
CSc 241	Data Base Systems (3) **or**
CSc 262	Programming Languages (3)

(20-21 credit hours)

*With approval, CSc 17, Structured Programming and Data Structures (4), can be substituted for CSc 11 and CSc 15 for a 17-18 credit hour minor.

Graduate Programs

Graduate programs of study provide a balance between formal classroom instruction and research and are tailored to the individual student's professional goals. The programs appeal to individuals with backgrounds in electrical or computer engineering, computer or information science, mathematics, or the physical sciences. Research is an essential part of the graduate program. Major research areas include:
Compound Semiconductor Microwave & Quantum Electronics
Microwave gallium arsenide monolithic integrated circuits, heterojunction device physics and materials. Ultra-high speed phenomena, modelling, packaging subsystem design. Submillimeter wave devices, cryogenic noise and magnetotransconductance investigations. Photonic devices, interactions and transmission. Tunnelling microscopy.
Microelectronics—Devices, Integrated Circuits, VLSI Design
Silicon integrated circuit technology, processing, fabrication and testing. CMOS, semiconductor device physics, small geometry VLSI, Josephson junction devices. VLSI logic design and verification, computer-aided (CAD), VLSI chip architecture. Non-linear circuit design.
Artificial Intelligence—Expert Systems
Expert systems; knowledge-based systems in design, electronics packaging, manufacturing, and construction; intelligent robotics; autonomous vehicles; natural language processing; AI programming languages; learning systems and mechanisms; data models and object-oriented systems; user

interfaces; decision-support systems; integration of symbolic and computational processing modes; database interfaces; CAD/CAM/CAE/CIM problems; cognitive science.
Information and Computer Engineering
Networking and distributed computing; architecture, protocol specification and verification, loading, routing and allocation, distributed processing, error control, security and protection; real-time processing; pipelining and scheduling, signal processing algorithms, VLSI architectures, speech compression and recognition, concurrent processing; fault tolerant computing; hardware/software redundancy, coding theory, verification and testing.

The Master of Science degree requires the completion of 30 credit hours of work which includes a six credit hour thesis for the E.E. degree and a three credit hour thesis for the C.S. degree. Special topics courses are restricted to six credit hours, and the C.S. degree requires CSc 302, Compiler Design, CSc 411, Advanced Programming Techniques, and CSc 403, Theory of Operating Systems. A program of study must be submitted in compliance with the graduate school regulations. An oral presentation of the thesis is required.

The Master of Engineering degree requires the completion of 30 credit hours of work, which includes design-oriented courses and an engineering project. A program of study must be submitted in compliance with the graduate school rules. An oral presentation of the project is required.

The Ph.D. degree in Electrical Engineering and the Ph.D. degree in Computer Science require the completion of 60 credit hours of work (including the dissertation) beyond the master's degree, the passing of a departmental qualifying examination appropriate to each degree within one year after entrance into the degree program, the passing of a general examination in the candidate's area of specialization, the admission into candidacy, and the writing and defense of a dissertation. Competence in a foreign language is not required.

Additional graduate program information may be obtained from the department's administrative assistant.

Departmental Courses

Courses are listed under the prefixes CSc and ECE. Generally, electrical engineering courses carry the ECE prefix and computer science courses carry the CSc prefix. Computer Engineering courses are likely to be found under either prefix. The reader is urged to consult both listings.

Computer Science (CSc)

For Undergraduate Students

CSc 11. Introduction to Structured Programming (3)
Algorithmic design and implementation in high-level, block-structured, procedure-oriented languages. No prior computing experience required.

CSc 15. Data Structures (4)
Continuation of CSc 11. Data structures using pointer variables. Examination of languages (typified by FORTRAN) not designed with structured programming in mind. Prerequisite: CSc 11.

CSc 17. Structured Programming and Data Structures (4)
Algorithmic design and implementation in high level, block-structured, procedure-oriented languages. Recursion, lexical programs, pointers, data structures, and their applications. Previous experience with programming required. NOTE: CSc 17 constitutes an accelerated course for students with some programming experience, which can be used as a prerequisite in place of CSc 11 and 15.

CSc 33. Principles of Computer Engineering (4) fall and spring
Microcomputer organization, architecture, and interfacing. Number systems, Boolean algebra, assembly language programming. Includes a software development laboratory. Prerequisite: Engr 1 or CSc 15 or CSc 17 or equivalent.

CSc 102. Foundations of Computing Science (3)
Elementary discrete structures; algorithmic structures; introduction to machine organization assemblers, loaders, languages. Prerequisite: CSc 11.

CSc 143. Foundations of Information Science (3)
Fundamental properties of information systems and theories governing information system design. Inherent data structures and representation of knowledge. Logic, data bases, and decision support systems. Real world applications.

CSc 181. Advanced Programming (3)
Advanced information structures, list processing, symbolic processing, basic formal language theory, elementary parsing and interpreting algorithms, assembly language, introduction to computer organization. Prerequisite: CSc 15 or 17.

CSc 190. Special Topics (1-3)
Supervised reading and research. Prerequisite: consent of the division head.

CSc 217. (EdT 417) Advanced Instructional Programming in PASCAL (3)
Continuation of structured programming in PASCAL. Special emphasis on the application of sound, color, and graphics in instructional courseware development. Prerequisite: CSc 11 or EdT 313.

CSc 221. Low-Cost Personal Retrieval Systems (3)
Systems for finding information quickly within a personal information collection. Applicable to collections gathered for study, research, hobby, or other purposes. Students develop systems for their own collections. Emphasizes nomechanical systems, but with some study of possible computer use, including personal computers. For non-computer science people; and also an introduction to retrieval for information science students.

CSc 230. Elementary Artificial Intelligence Applications (3)
How computers combine elementary operations to do complex jobs. How computers play chess, compose music, simulate psychiatrists, produce medical diagnoses. No previous knowledge of computers required.

CSc 241. Data Base Systems (3) fall
Data base concepts in terms of formal logic. Knowledge representation and deduction. Data base integrity. Query languages. Prerequisite: CSc 11 or approval of the division head.

CSc 251. Computers and Language (3)
Language-related computer applications drawn from a variety of areas such as cryptography, work-processing, linguistics, and artificial intelligence. Prerequisite: CSc 11 or permission of the division head.

CSc 252. Computers and Society (3)
A general nontechnical survey of the impact of computers on modern society. Special attention is given to the use of large-scale data banks and retrieval systems, the problems of privacy and file security, and the impact of automation on everyday life.

CSc 261. (Math 261) Discrete Structures (3)
Topics in discrete structures chosen for their applicability to computer science and engineering. Sets, propositions, induction, recursion; combinatorics; binary relations and functions; ordering, lattices and Boolean algebra; graphs and trees; groups and homomorphisms. Various applications. Prerequisites: Math 21 and either CSc 11 or Engr 1.

CSc 262. Programming Languages (3) fall and spring
Use, structure and implementation of several programming languages. Prerequisite: CSc 15 or 17.

CSc 301. Descriptive Linguistics (3) fall
Techniques for the description of the phonology, morphology, and syntax of natural languages. Special attention to transformational generative grammar. Rubenstein

CSc 302. Compiler Design (3) fall
Principles of artificial language description and design. Sentence parsing techniques, including operator-precedence, bounded-context, and syntax-directed recognizer schemes. The semantic problem as it relates to interpreters and compilers. Dynamic storage allocation, table grammars, code optimization, compiler-writing languages. Prerequisite: CSc 181.

CSc 303. Operating System Design (3)
Assemblers, executive systems, multiprogramming, time-sharing. Concurrent tasks, deadlocks, resource sharing. Construction of a small operating system. Prerequisites: CSc 181 and 211.

CSc 310. (Educ 320, Psyc 320) Psycholinguistics (3)
Study of the experimental and observational literature on psychological processes involved in the production, comprehension and use of language by adults. Rubenstein

CSc 311. (EdT 311) Instructional Computing in BASIC (3)
Introduction to microcomputers and their applications in educational settings. Special emphasis on a structured approach to programming in the BASIC language and on applications of principles of instructional design to the development of microcomputer-based instructional materials. No prior experience with microcomputers or programming is assumed.

CSc 313. Computer Graphics (3)
General principles; algorithms; display devices and organization; methods of interaction; design of visual interactive systems. Prerequisite: CSc 181.

CSc 318. Computing Algebra (3)
Continuation of 317. Formal languages, parsing, semantics. Prerequisite: CSc 261 or Math 243.

CSc 326. Human Information Processing (3)
Attention, perception, memory, problem solving, decision making. Focused toward application in artificial intelligence and instructional design.

CSc 327. Artificial Intelligence Applications (3)
Computer reasoning, knowledge use (expert systems), and natural language understanding. Emphasis on systems successful in practical use or experimentally. Student development of small-scale systems (programming optional).

CSc 328. Human Factors (3)
The cognitive processes relevant to the design and implementation of computer systems; representation of the human role in automation; hardware and software design of interfaces with computer system users; applications of artificial intelligence; human factors issues in robotics.

CSc 335. Micro Processor Software Design (3)
Design and development of software for small computers. Interfacing, real-time processing, software-hardware tradeoffs and program efficiency, performance and evaluation. Applications to monitors, operating systems, interpreters, translators and networks. Prerequisites: CSc 33 and 181.

CSc 338. Data Retrieval Systems (3)
The design, development, and operation of computer-based systems for the retrieval and manipulation of numerical and non-numerical data contained in machine-readable databases.

CSc 340. (Math 340) Design and Analysis of Algorithms (3)
Algorithms for searching, sorting, counting, graph and tree manipultation, matrix multiplication, scheduling, pattern matching, fast Fourier transform. Minimum time and space requirements are established, leading to the notion of abstract complexity measures and the intrinsic complexity of algorithms and problems, in terms of asymptotic behavior. The question of the correctness of algorithms is also treated. Prerequisite: CSc 15 or Math 23 or consent of the division head.

CSc 343. (EdT 443) Microcomputer-Aided Instruction (3)
Design and development of microcomputer-assisted instructional units. Students design, program and test microcomputer-aided instructional units as drill, practice, tutorial, and simulation exercises.

CSc 351. (EdT 351) Cognitive Science (3)
A synthesis of elements of artificial intelligence, psychology and linguistics; concerned with models of the acquisition, representation, storage, retrieval and application of knowledge.

CSc 365. Natural Language Understanding (3)
Design of natural language systems. Survey and implementation of current linguistic and artificial intelligence techniques for morphology, syntax, semantics and discourse. Consideration of interface with nonlinguistic applications, such as databases, robotics. Prerequisite: CSc 181. Blank

CSc 368. Artificial Intelligence (3) spring
The use of LISP and related languages to simulate intelligence on computers. Prerequisite: CSc 262 or approval of the division head. Rayna

CSc 371. Readings and Project I (3)
Supervised independent work.

CSc 372. Readings and Project II (3)
Supervised independent work on a major project.

CSc 374. Information Retrieval Theory (3)
An introduction to the problems of computerized information storage and retrieval systems. Special attention is given to the logical and mathematical techniques for automatic text-processing, file generation, and inquiry negotiation.

CSc 385. (Psyc 385) Programming Applications to Psychological Instrumentation (3) spring
The computer in the psychological laboratory: PASCAL on the Apple computer; real-time acquisition of data; computer control of experiments. Prerequisite: CSc 11 or 17. Kay

CSc 390. Special Topics (1-3) offered as required
An opportunity for advanced work through supervised reading and research. Prerequisite: consent of the division head. May be repeated for credit.

For Graduate Students

CSc 402. (Psyc 448) Seminar in Psycholinguistics (3)
Selected topics in psycholinguistics examined in depth and in detail. Prerequisite: CSc 310. Rubenstein

CSc 403. Theory of Operating Systems (3)
Principles of operating systems with emphasis on hardware and software requirements and design methodologies for multi-programming systems. Global topics include the related areas of process management, resource management, and file systems. Prerequisite: CSc 303 or equivalent. Ota

CSc 409. Theory of Automata and Formal Grammars (3)
Finite automata. Pushdown automata. Relationship to definition and parsing of formal grammars. Prerequisite: CSc 318.

CSc 411. Advanced Programming Techniques (3) spring
Deeper study of structured programming, data structures, back-tracking, recursion. Applications of basic concepts of automata theory and formal language theory. Fundamental principles of 'large program' design. Several major programming assignments using pascal. Prerequisite: CSc 15 or 17 or consent of the division head. Gulden

CSc 413. Robotics and Intelligent Machines (3)
Software aspects of robot and intelligent machine controls. Fundamental control issues through language and artificial intelligence implementations.

CSc 414. Expert Systems (3)
The design and development of knowledge-based expert systems. Rule-based protocols. Knowledge engineering. Programming application. Prerequisite: CSc 368.

CSc 415. Database Topics (3)
Design issues in integrated database systems. Database entities and their relationships. Prerequisite: CSc 241 or equivalent.

CSc 417. Topics in Information Retrieval (3)
Selected topics in the design of advanced retrieval systems. Prerequisite: CSc 241 or Equivalent.

CSc 419. Subject Document Retrieval (3)
Techniques and systems for retrieval of documents in response to subject requests. Request negotiation techniques, document indexing (coordinate, relational, weighted), Bolean and weighted-term searching methods, thesauri and classifications as aids to negotiation, indexing and searching, on-line retrieval, and citation indexes. O'Connor

CSc 422. Advanced Topics in Compiling (3)
Topics from general parsers, attributed translation, attribute grammars, two-level grammars, expression optimization, data flow, code optimization, compiler compilers, implementation languages, multi-tasking languages. Prerequisite: CSc 302 or consent of the division head. Gulden

CSc 437. Program Semantics (3)
Theories and techniques of program semantics and program verification. Topics may be chosen from denotational semantics, operational semantics, Floyd-Hoare semantics, temporal logic, dynamic logic, algebraic semantics, continuous semantics, recursive function theory or a current semantic theory. Gulden

CSc 465. Computational Linguistics (3)
Design of natural language systems. Application of linguistic theory and artificial intelligence techniques to development of natural language parsers and generators. Analysis of efficiency and extendability of such systems; practical applications. Prerequisite: CSc 262. Blank

CSc 492. Special Topics (3)
Topics in computer science not treated in other courses.

Electrical Engineering (ECE)

For Undergraduate Students

ECE 81. Principles of Electrical Engineering (4) fall and spring
Circuit elements and laws. Behavior of simple linear networks. Characteristics of electronic devices and device models. Introduction to functional circuits, such as operational amplifier and logic devices. Principles of electromechanical energy conversion and power systems. Includes a weekly session for review and discussion. Prerequisite: Math 22. Corequisite: Phys 21.

ECE 108. Signals and Systems (4) spring
Continuous and discrete signal and system descriptions using signal space and transform representations. Includes Fourier series, continuous and discrete Fourier transforms, Laplace transforms, and z-transforms. Introduction to sampling. Prerequisite: ECE 81.

ECE 111. Proseminar (1) fall
A weekly seminar to acquaint students with current topics in electrical and computer engineering. Students prepare and present oral and written reports that are judged on quality and presentation as well as technical content. Prerequisite: senior standing.

ECE 116. Software Engineering (3) spring
Software methodologies, data structures, searching, sorting, recursion, trees and linked lists. Prerequisite: CSc 17 or equivalent.

ECE 121. Electronic Circuits Laboratory (2) fall
One lecture and one laboratory per week. Experiments illustrating the principles of operation of electronic devices and their circuit applications. Basic electronic instrumentation and measurement techniques. Corequisite: ECE 123.

ECE 123. Electronic Circuits (3) fall
Methods for analyzing and designing circuits containing electronic devices. Topics include device models, basic amplifier configurations, operating point stabilization, frequency response analysis, and computer-aided analysis of active circuits. Prerequisite: ECE 108.

ECE 125. Circuits and Systems (3) fall
Formulation of discrete and continuous circuit equations. Complete solutions of difference and differential equations. Network theorems. State space description of discrete and continuous linear systems. Computer-aided circuit analysis. Prerequisites: ECE 108 and Math 205.

ECE 126. Physical Electronics (3) spring
Introduction to wave mechanics, statistics and the theory of solid-state materials. Principles of electron emission and conduction and their applications. Treatment of semiconductor devices including: p-n junctions, junction luminescence, p-n lasers, Impatt and Gunn devices, and Hall devices. Prerequisite: ECE 81.

ECE 136. Electromechanics Laboratory (3) spring
Two lecture and one laboratory per week. An experimental introduction to electromechanical energy conversion. Basic concepts of magnetic fields and forces and their application to electrical apparatus including electromechanical transducers, transformers, AC and DC machines. Prerequisite: ECE 81.

ECE 138. Digital Systems Laboratory (2) spring
One laboratory and one lecture per week. Digital measurements, digital instrumentation, logic testing. Characteristics of and design techniques for combinational logic and sequential circuits. Prerequisite: CSc 33 or equivalent.

ECE 151. Senior Laboratory I (2) fall
Laboratory projects in any phase of electrical and computer engineering, frequently in the areas of digital systems, communications, instrumentation, electronic circuits, and software. Projects are selected from topics suggested by the students, staff, or industrial concerns. Two three-hour sessions per week. Prerequisite: senior standing.

ECE 152. Senior Laboratory II (2) spring
Two choices open, each occupying two three-hour sessions per week. (1) Project laboratory. Similar to ECE 151.
(2) Microwave laboratory. Introduction to the standard techniques of measurement in the microwave range, such as measurement of impedance with the slotted line and the hybrid tee; two-port parameters; attenuation by substitution and heterodyning. Corequisite: ECE 346 for choice (2).

ECE 162. Electrical Laboratory (1)
Experiments on circuits, machines, and electronic devices. Elementary network theory. Survey laboratory for students not majoring in electrical or computer engineering. Prerequisite: ECE 81.

ECE 201. Computer Architecture (3) spring
Digital building block, conventional computer structure and information flow. Mechanization of arithmetic, storage, and control functions. Input-output systems and controllers.

Priority interrupt, direct memory access and other overlapping techniques. Architecture of small ('mini') computers; key features of large ('maxi') machines. Digital design simulation. Prerequisite: CSc 33.

ECE 202. Introduction to Electromagnetics (3)
Elements of vector analysis, Coulomb's law, Biot-Savart's and Ampere's laws, Lorentz Forces, Laplace's and, Maxwell's equations, boundary conditions, methods of solution in static electric and magnetic fields, including finite element numerical approach. Quasistationary fields, inductance. Prerequisite: Math 205, Phys. 21.

ECE 203. Introduction to Electromagnetic Waves (3)
Uniform plane waves in free space and in materials, skin effect. Waves in transmission lines and waveguides, including optical fibers. Energy and power flow, Poynting's theorem. Reflection and refraction. Resonators. Radiation and diffraction. Prerequisite: ECE 202.

ECE 212. Control Theory (3) fall
Introduction to feedback control. Dynamic analysis of linear feedback systems in the time and frequency domain, with emphasis on stability and steady-state accuracy. Major analytical tools: signal-flow graphs, root-locus methods. Nyquist plot, Bode analysis. Cascade compensation techniques. Introduction to sampled data and state-variable concepts. Prerequisite: ECE 125.

ECE 233. Power System Analysis I (3) fall
Determination of transmission line constants: transmission line equations. Synchronous generator representation during steady state and transient conditions. Network reduction by matrix partitioning, network solutions by matrix transformations. Symmetrical components and system faults. Sequence impedances of transmission lines, transformer banks and synchronous generators. Prerequisite: ECE 136.

ECE 234. Power System Analysis II (3) spring
Application of short-circuit impedamce matrix to fault studies. Numerical methods for solution of the load flow problem. Economic dispatch and unit commitment. Basic system stability consideration. Prerequisite: ECE 233.

ECE 244. Communication Networks (3)
Introductory theory of two-terminal and four-terminal network synthesis. Transmission lines as network elements. Analog and digital filter theory. Prerequisites: ECE 123 and 125.

ECE 303. (Mat 323) Electrical and Physical Characterization of Defects in Semiconductors (3)
Basic concepts of solid state physics applied to P-N junction theory. Topics include influence of material growth techniques on defect origination; dislocations induced by diffusion; oxidation-induced stacking faults; the role of imperfections on pipe leakage and soft breakdowns. The relation of materials, defects and processing will be highlighted. Jaccodine

ECE 305. (Mat 321) Failure Analysis of Semiconductor Devices (3)
Fundamental degradation and failure mechanisms that affect the reliability of semiconductor devices. The use of scanning and transmission electron microscopy to examine these mechanisms. Lectures and laboratory. Prerequisite: consent of the department chairperson. Norian

ECE 307. Transistor Circuit Applications (3)
Review of static and dynamic behavior of p-n junctions. Transistor physical electronics, volt-ampere characteristics, and circuit models. Dependence of circuit-model parameters on structure and operating conditions. Tuned amplifiers, feedback amplifiers, and oscillators. Prerequisite: ECE 123.

ECE 308. Electronic Device Modeling Theories (3) fall
Models of various electronic devices will be developed and evaluated. Devices such as Schottky and p-n diodes, IGFET, JFET, MESFET, bipolar transistors, and charged-coupled circuits will be covered. Prerequisite: ECE 126. Leenov or Norian

ECE 316. Microcomputer System Design (3) spring
Content is primarily hardware oriented, but software issues are covered where required. Includes performance characteristics of the more popular devices on the market today. Specific topics include: basic microcomputer structure, bus interconnections, memory systems, serial and parallel interfacing, CRT controllers, interrupt structures, DMA. Prerequisite: CSc 33. Holzinger

ECE 319. Digital System Design (3)
Design techniques on the register transfer level, with emphasis on VLSI applicability. Definition of AHPL and its use in the design of simple CPU's. Implementation of microprogramming, intersystem communications, and interrupt. Interfacing with peripherals. Design verification and simulation. Prerequisite: CSc 33. Susskind

ECE 320. Logic Design (3)
Review of basic switching theory. Sequential machine synthesis and asociated hardware considerations. Topics such as usage of PLA's and other canonic forms; specification and design of networks not represented by gates; introduction to the theory of logic network simulation and test generation. Prerequisite: CSc 33. Susskind

ECE 323. Applied Large Scale Integrated Circuits (3) fall
Operation of various families of logic devices. Study of static and dynamic interconnection problems, including pulse propagation on transmission lines. Static and dynamic RAM's, ROM's, PLA's, SR's, FIFO's and microprocessors. Holzinger

ECE 332. Design of Linear Electronic Circuits (3) spring
Introduction to a variety of linear design concepts and topologies, with contemporary audio networks providing many of the concrete examples. Topics include low- and high-level preamps; equalizers and filters; mixers; voltage-controlled amplifiers; input and output stage modifications; power amplifiers; analog switching and digital interface circuitry. Prerequisite: ECE 355. Frey

ECE 342. Communication Theory (3) spring
Theory and application of analog and digital modulation. Sampling theory with application to analog-to-digital and digital-to-analog conversion techniques. Time and frequency division multiplexing. Introduction to random processes including filtering and noise problems. Introduction to statistical communication theory with primary emphasis on optimum receiver principles. Prerequisites: ECE 125 and Math 309 or Math 231. Fritchman

ECE 343. Digital Signal Processing (3) fall
Study of one- and two-dimensional orthogonal signal expansions and their discrete representations, including the Discrete Fourier Transform and Walsh-Hadamard Transform. Development of fast algorithms to compute these, with applications to feature extraction and two-dimensional image processing. Introduction to the z-transform representation of numerical sequences with applications to input/output analysis of discrete systems and the design of digital filters. Analysis of the internal behavior of discrete systems using state variables for the study of stability, observability and controllability. Prerequisite: ECE 125. Fritchman

ECE 345. Speech Synthesis and Recognition (3) fall
Application of digital technology to generation and recognition of speech by machines. The analytical tools required for digitizing and encoding speech signals; the methods currently used for synthesizing and recognizing speech; various hardware products available to perform these tasks. Holzinger

ECE 346. Microwave Circuits and Techniques (3) spring
Impedance transformation along waveguides. Matching techniques. Applications of Smith Chart. Resonators as circuit

elements. Scattering and transfer matrices. S-parameter design of transistor amplifiers. Stability. Noise. Reflection type amplifiers. Prerequisite: ECE 203 or equivalent. Eberhardt

ECE 350. Special Topics (3)
Selected topics in the field of electrical and computer engineering not included in other courses. May be repeated for credit.

ECE 351. Microelectronics (3)
Technology of semiconductor devices and of integrated circuits, including crystal growth and doping, phase diagrams, diffusion, epitaxy, thermal oxidation and oxide masking, photolithography, thin film formation. Effects of these processes on the design of transistors and integrated circuits. Prerequisite: ECE 126. Thompson

ECE 355. Applied Integrated Circuits (3)
Emphasis on understanding of terminal characteristics of integrated circuits with excursion into internal structure only as necessary to assure proper utilization in system design. Classes of devices studied include operational amplifiers, digital-to-analog and analog-to-digital converters, linear multipliers, modulators, and phase-locked loops. Prerequisites: ECE 123 and 125. Holzinger

ECE 361. Introduction to VLSI Circuits (3)
Design of very large scale digital integrated circuits, with primary emphasis on CMOS Standard Cell design. MOS transistor theory, CMOS technology, circuit layout and design rules, parasitic parameter extraction, analysis and performance of logic and transmission gates, CMOS circuit and logic design, VLSI system organization. Computer aids for circuit and timing simulation using SPICE or SLICE, logic system verification and performance using PROTEUS, and CAD layout using an Applicon interactive graphics system. Two one-hour lectures and three hours of design automation laboratory per week. Prerequisites: ECE 121 and 123. Hielscher

ECE 387. (ChE 387, ME 387) Digital Control (3) spring
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability state feedback control. (2 lectures and one laboratory per week) Prerequisite: ChE 386 or ECE 212 or ME 342 or consent of instructor.

For Graduate Students

ECE 404. Computer Networks (3)
Study of architecture and protocols of computer networks. The ISO model; network topology; data-communication principles, including circuit switching, packet switching and error control techniques; sliding window protocols, protocol analysis and verification; routing and flow control; local area networks; network interconnection; topics in security and privacy. Tzeng

ECE 407. Linear and Nonlinear Optics (3)
Gaussian beams. Optical waveguides and resonators. Introduction to laser physics. Crystal optics with attention to nonlinear effects. Harmonic and subharmonic generation. Parametric amplifications. Brillouin and Raman scattering. Classical diffraction theory. Holography with applications. Eberhardt

ECE 411. Information Theory (3)
Introduction to information theory. Topics covered include: development of information measures for discrete and continuous spaces study of discrete-stochastic information courses, derivation of noiseless coding theorems, investigation of discrete and continuous memoryless channels, development of noisy channel coding theorems. Fritchman

ECE 412. Advanced Digital Signal Processing (3)
Design and analysis of signal processing algorithms, Number theoretic foundations of algorithm design, bilinear algorithms, computational techniques for digital filtering and convolution, Fourier transform and its algorithms, number theoretic transforms and its applications to digital filtering, general and special purpose signal processor designs, application specific techniques in signal processing. Prerequisite: ECE 343 or consent of the department chairman. Wagh

ECE 415. Numerical Processors (3)
Design strategies for numerical processors, cellular array adders and multipliers, conditional sum and carry-save asynchronous processors, data recoding and Booth's algorithms, use of alternate numerical bases, CORDIC trigonometric calculator, accumulator orientations, bit slice and bit-sequential processors, pipelining and parallel processing considerations. Prerequisite: ECE 201. Wagh

ECE 425. Power System Analysis (3)
Basic concepts including per-unit representations; symmetrical three-phase transmission systems; power transformers; three-phase synchronous generators; transmission lines; modeling and power flow analysis of systems in steady state.

ECE 426. Power System Dynamics and Stability (3)
State space models of synchronous generator; model of a simple power system with a single machine connected to infinite bus; model of multi-machine power system; dynamic and transient stability of single and multi-machine systems. Prerequisite: ECE 425 or equivalent.

ECE 427. Power System Control (3)
Control problems for power systems in the steady state; automatic voltage regulators; load frequency control of single area system, load frequency control of multi area system; automatic generation control in interconnected power system; power system intrumentation; load control centers. Prerequisite: ECE 425 or equivalent.

ECE 428. Power System Protection (3)
Surge phenomena in power systems; symmetrical faults; unbalanced system analysis; different types of relays; solid state protection devices; transmission line protection; protection of generators and motors; transformer protection. Prerequisite: ECE 425 or equivalent.

ECE 429. Power System Optimization (3)
The problem of optimal economic operation of a power system; modeling for optimum operations; review of linear and non-linear programming; elements of dynamic programing and maximum principle; optimization of thermal, hydro and hydro-thermal systems. Prerequisite: ECE 425 or equivalent.

ECE 431. Topics in VLSI Logic Design (3)
Major topics from which coverage is selected: representation of large logic networks; network forms; test generation and built-in testing; logic simulation; design for testability and fault-tolerance. Prerequisite: ECE 320 or equivalent. Susskind

ECE 432. Finite State Machines (3)
Description of sequential behavior; Gendanken experiments; error control; information losslessness, iterative systems. Synthesis of sequential machines in canonic forms and as asynchronous circuits. Prerequisite: consent of department chairperson. Susskind

ECE 433. (ChE 433, ME 433) State Space Control (3) fall
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin's Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal openloop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds.

Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or ChE 386 or consent of instructor.

ECE 434. (ChE 434, ME 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feedforward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 435. Error-Correcting Codes (3)
Error-correcting codes for digital computer and communication systems. Review of modern algebra concentrating on groups and finite fields. Structure and properties of linear and cyclic codes for random or burst error correction covering Hamming, Golay, Reed-Muller, BCH and Reed-Solomon codes; construction of Goppa codes and their recent generalizations. Decoding algorithms and implementation of decoders. Prerequisite: CSc 317 or equivalent. Tzeng

ECE 436. (ChE 436, ME 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 437. (ChE 437, ME 437) Stochastic Control (3)
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gausian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ECE 444. Microwave Devices (3)
Basic theory, design theory and intuitive understanding is developed for passive and active devices and special circuitry used today in microwave systems: circulators, isolators, directional coupler, periodic structures, parametric amplifiers, masers, magnetrons, and klystrons. Semiconductor devices are only discussed by their terminal characteristics. Eberhardt

ECE 445. Applied Electromagnetic Theory (3)
Advanced electromagnetics. Emphasis on planar structures for integrated circuit technology at microwave through optical wavelengths. Examination of the properties and applications of structures such as microstrip, slotline, dielectric waveguides, isolators, phase shifters, circulators and couplers. Bolle

ECE 446. Millimeter and Submillimeter Wave Devices (3)
Study of millimeter and submillimeter wave system components. Theoretical considerations, modelling, measurement techniques and design considerations is explored at a level consonant with the background of the students enrolled. The work is based on journal literature. Prerequisite: ECE 445 or consent of instructor. Bolle

ECE 447. Nonlinear Phenomena (3)
Investigation of nonlinear effects in active and passive lumped and distributed circuits with emphasis on methods of analysis as well as physical understanding of jump phenomena, van der Pol's theory, stability criteria, phase locking. Transmission line and optical waves in nonlinear media; shock waves, harmonic generation and optical parametric amplification. Eberhardt

ECE 450. Special Topics (3)
Selected topics in electrical and computer engineering not covered in other courses. May repeated for credit.

ECE 451. Physics of Semiconductor Devices (3)
Transport theory, lattice vibrations, electronic conduction, thermoelectric effects. Theory of recombination. Energy band structure. Applications to p-n junctions. Prerequisites: Phys 31 and ECE 126 or equivalent. Decker or Leenov

ECE 452. Theory of Microwave Semiconductor Devices (3)
Hot electrons, secondary ionization, avalanche breakdown, electron transfer by intervalley scattering. Applications to microwave components such as avalanche and Gunn diodes, Schottky diodes, tunnel diodes and PIN diodes. Prerequisite: ECE 451. Decker

ECE 454. Theory of Optoelectronic Devices (3)
Optical electronics. Theory of radiation, radiative absorption and emission in semiconductors. Applications to optical electronic devices: electroluminescence, light-emitting diodes, lasers. Detection and modulation of optical radiation, solar cells and photodetectors. Prerequisite: ECE 451. Decker

ECE 455. Theory of Metal Semiconductor Diodes and Field Effect Transistors (3)
Properties of metal semiconductor contacts, ohmic contacts, Schottky barriers, minority carrier injection, etc.. Properties of metal semiconductor field effect transistors (MESFETS), equivalent circuits, applications to microwave amplifiers, oscillators, switching circuits, etc. Prerequisite: ECE 451. Decker

ECE 460. Engineering Project (3-6)
Project work in an area of student and faculty interest. Selection and direction of the project may involve interaction with industry. Prerequisite: consent of department chairperson.

ECE 461. Theory of Electrical Noise (3)
Definitions: noise temperature, spectral density. Noise sources: quantum, thermal, shot, generation-recombination, flicker noise. Representation and optimization of noisy networks. Prerequisites: Phys 31 and ECE 126. Decker

ECE 463. Design of Microwave Solid State Circuits (3)
Equivalent circuit modeling and characterization of microwave semiconductor devices, principles of impedance matching, noise properties and circuit interaction, introduction to the design of high power and non-linear circuits. Decker

ECE 476. Analysis and Design of Analog Integrated Circuits (3)
Device and circuit models of bipolar and field effect transistors; bipolar and MOS integrated circuit technology; passive components; parasitic and distributed elements; amplifier gain stages; subthreshold gain stages; current sources and active loads; temperature and supply-independent biasing; output stage design; frequency response and slew rate limitation; operational amplifier and analog multiplier design. Circuit simulation using SPICE or SLICE. Prerequisite: ECE 308 or equivalent. Hielscher

ECE 478. Analysis and Design of Digital Integrated Circuits (3)
Large signal models and transient behavior of MOS and bipolar transistors. Basic inverter and logic gate circuits. Noise margins, operating speed, and power consumption of various logic families, including MOS, CMOS, saturated logic TTL, ECL, and I^2L. Regenerative logic circuits and digital memories. Circuit design and computer aided circuit analysis for LSI and VLSI circuits. Prerequisite: ECE 308. Hielscher

ECE 483. Advanced Semiconductor Devices for VLSI Circuits (3)
Theory of small geometry devices for VLSI circuits. Emphasis of MOS bipolar device static and dynamic electrical

characteristics. Carrier injection, transport, storage, and detection in bulk and interfacial regions. Limitations of physical scaling theory for VLSI submicron device structures. MOS physics and technlogy, test pattern device structures, charge-coupled devices, MNOS nonvolatile memory devices, and measurement techniques for device and process characterization. The influence of defects on device electrical properties. Prerequisite: ECE 451. White

ECE 484. Dielectric Materials in VLSI and Optoelectronics (3)
Electronic and optical properties of silicon dioxide and other dielectric materials, including optical excitations, charge carrier transport and trapping, and interface phenomena. Applications to dielectric crystal, film, and fiber structures in integrated circuit, optical communication, and VLSI technologies. Emphasis on specific topics of current interest. Prerequisite: ECE 451 or equivalent. Feigl

ECE 486. Integrated Solid-State Sensors (3)
The physical operation of sensor-based, custom integrated circuits. Emphasis on the integration of sensors, analog, and digital circuits on a silicon chip with CMOS technology. Sensors include photocells, electrochemical transducers, strain gauges, temperature detectors, vibration and velocity sensors, etc. Analysis of sensor-circuit performance limits including signal-to-noise, frequency response, temperature sensitivity, etc. Examples of sensor-based, custom I.C.'s are discussed and analyzed with CAD modeling and layout. Prerequisite: ECE 451. White

ECE 493. Solid State Electronics Seminar (3)
Discussion of current topics in solid-state electronics. Topics selected depend upon the interests of the staff and students and are allied to the research programs of the Sherman Fairchild Laboratory for Solid State Studies. Student participation via presentation of current research papers and experimental work. Prerequisite: consent of instructor. May be repeated for credit. Staff

Cooperative Undergraduate Education

Certain departments offer limited opportunities to students for cooperative work assignments with industrial or business firms and government agencies. In all cases cooperative work assignments are optional on the part of the student and there is no obligation for the student to accept permanent employment nor for the cooperating organization to offer permanent employment.

When on a cooperative assignment, the student must register for the non-credit course, Cooperative Undergraduate Education, to maintain continuous student status. The fee for this course is established by the University Treasurer. Participation in a cooperative education program does not relieve the student from any regular requirement for the academic curriculum in which he or she is enrolled.

Details of cooperative arrangements vary with different curricula. Each department offering cooperative education will provide the details of its program in writing to interested students.

200. Cooperative Undergraduate Education (0)
Supervised cooperative work assignment to obtain practical experience. Prerequisite: Consent of the department chairperson.

Counseling

See listings under Education.

Economics

Professors. J. Richard Aronson, Ph.D. (Clark), *Clayton Professor;* Nicholas W. Balabkins, Ph.D. (Rutgers); Alvin Cohen, Ph.D. (Florida); Gerald Garb, Ph.D. (Berkeley); John D. Keefe, M.A. (Miami); John R. McNamara, Ph.D. (Rensselaer); Eli Schwartz, Ph.D. (Brown), *MacFarlane Professor;* Robert J. Thornton, Ph.D. (Illinois), *chairman.*
Associate professors. Thomas J. Hyclak, Ph.D. (Notre Dame); Jon T. Innes, Ph.D. (Oregon), *major advisor and curriculum director;* Arthur E. King, Ph.D. (Ohio State); R. Allen Moran, Ph.D. (Massachusetts); Vincent G. Munley, Ph.D. (S.U.N.Y.); Warren A. Pillsbury, Ph.D. (Virginia).
Assistant professors. Colleen M. Callahan, Ph.D. (North Carolina); Frank R. Gunter, Ph.D. (Johns Hopkins); Ram Mudambi, Ph.D. (Cornell); Larry W. Taylor, Ph.D., (North Carolina).
Adjunct professors. Finn B. Jensen, Ph.D. (Southern California); Ching Sheng Shen, Ph.D. (North Carolina).

Though economics is variously defined, modern-day definitions generally suggest that it is the study of the principles that govern the efficient allocation of resources. One of the greatest of the 19th Century economists who did much to uncover these principles suggested a broader definition. Alfred Marshall described economics as "a study of mankind in the ordinary business of life . . . a part of the study of man." This dual nature of economics, technical and humanistic, is reflected in the fact that at Lehigh the economics major is available to students in the College of Arts and Science as well as in the College of Business and Economics.

As the description below suggests, the economics program is exceptionally flexible once one moves beyond the sophomore year. This flexibility allows the major to be adapted easily to the needs of students with widely varying goals. Although many students choose the economics major in order to secure a firm foundation in economics and finance before entering the business world, many others choose it in preparation for law school or as a complement to their major in government, history, international relations, journalism, mathematics, urban studies, or other disciplines. Naturally, many students who major in economics do so with the intent of pursuing graduate work at the master's or doctor of philosophy levels; others simply want to become "economically literate" in a world where such literacy is increasingly in demand.

At the same time that the program provides flexibility, it also consists of a substantial core of economic theory and related courses. This assures that the student who is uncertain concerning career goals will obtain a broad education in economics and business no matter what upper-level courses are chosen.

Students who are interested in designing a major program in economics suitable to their needs should consult with the major advisor and curriculum director.

Major in College of Business and Economics

Students in the College of Business and Economics electing to major in economics must take the College core courses as listed on page 35. They must also take at least 15 credit hours of 300 level economics courses beyond the core requirements. These courses may be chosen so as to form an area of specialization or to provide a broad exposure to the various aspects of the discipline. In any case, students should consult with the major advisor in forming their programs.

Major in College of Arts and Science

Required Courses (28 credits)

Eco 1	Economics (4)
Math 41, 44*	BMSS Calculus I and II (6)
Acct 51	Introduction to Financial Accounting (3)
Eco 105	Intermediate Microeconomic Analysis (3)
Eco 119	Intermediate Macroeconomic Analysis (3)
Eco 145	Statistical Methods (3)
Eco 229	Money and Banking (3)
Fin 225	Business Finance (3)

*Students who wish to take mathematics beyond calculus should substitute Math 21, 22, and 23 for this requirement.

Elective Courses (15 credits)

Students must take 15 credit hours of 300 level economics courses beyond the requirements listed above. Upper-level finance courses may be substituted for economics courses with the approval of the major advisor.

Minor in Economics

A minor in economics consists of 15 credit hours beyond Economics 1. Required courses in the minor are: Economics 105, 119 and 229. Elective courses must be chosen from among the 300-level economics offerings. This minor is available only to students in the College of Arts and Science and in the College of Engineering and Applied Science. Interested students in the former college should contact Prof. Jon Innes; those in the latter college should contact Prof. Vincent Munley.

Undergraduate Courses In Economics

1. Economics (4)
A course in the principles of economics. General topics covered are: the determination of national income; the determination of relative prices; money and banking; monetary and fiscal policy; and government finance. Eco 1 is a prerequisite for all subsequent courses in economics.

101. (Mgt 101) Introduction to Quantitative Methods (3)
Mathematical concepts within a business and economics framework: linear algebra, partial derivatives, constrained optimization, and integral calculus. Meets mathematics prerequisite for entering students in the master of business administration program. Not available for credit to undergraduates in the College of Business and Economics.

105. Intermediate Microeconomic Analysis (3)
Determination of prices in terms of the equilibrium of the business enterprise and consumer choice in markets of varying degrees of competition; analysis of market structures; rent, interest and profits.

119. Intermediate Macroeconomic Analysis (3)
Macroeconomic measurement, theory and policy. The use of alternative macroeconomic models to analyze inflation, unemployment, economic growth, the balance of payments, and exchange rate determination.

145. Statistical Methods (3)
Descriptive statistics, probability and probability distributions, sampling, estimation, hypothesis testing, regression and correlation, analysis of variance, nonparametric tests, and index numbers.

For Advanced Undergraduates And Graduate Students

229. Money and Banking (3)
A course dealing with the nature and functions of money, commercial banking, and central banking. The course provides a systematic framework within which current and past monetary policies can be examined and evaluated.

303. Economic Development (3)
The principal determinants of economic development theories are examined. Most of the theories are applicable to both the advanced industrial societies and to the poorer nations, but the emphasis is on the developmental process of the countries of the Third World. Cohen

305. The Economic Development of Latin America (3)
The course examines the forces at work in the development process in Latin America. Variables considered include the social and political as well as the economic ones. Theories are presented along with their application via the examination of country case studies. Cohen

309. Comparative Economic Systems (3)
An analysis of the economic, institutional, and political dimensions of non-market economies in the Soviet Union and China. Balabkins

310. Economic Evolution (3)
Structural changes, social transformation, and sources of the long-term growth of the U.S. economy. Balabkins, Thornton

311. Environmental Economics (3)
Economic policies for environmental protection. The optimal development of natural resources. The relationship between economic growth and environmental degradation. Case studies in water-quality management. McNamara

312. Urban Economics (3)
The analysis of economic problems related to urban areas; the nature and function of cities; the economic and spatial characteristics of urban activity. Pillsbury

313. History of Economic Thought (3)
Study of the evolution of economic science. Critical analysis of the contributions of major economists from the 18th through the 20th centuries. Cohen, Schwartz

314. Energy Economics (3)
The economic theory of natural resource allocation over time. Economics of exhaustible and renewable resources. Environmental effects of energy production and consumption. Government regulation of the energy industry. Computer models for energy system forecasting and planning. McNamara

315. Industrial Organization (3)
Structure of American industry. Development of economic models to describe behavior in markets with varying degrees of competition. Technological innovation, relationship between industry concentration and rates of return on capital, role of information and advertising, dynamics of monopoly and oligopoly pricing. Prerequisite: Eco 105. Mudambi, Garb

332. (Fin 332) Monetary-Fiscal Policy (3)
Monetary, credit and fiscal policies of governments and central banks with particular reference to the policies of the United States Treasury and the Federal Reserve System. Prerequisite: Eco 119 or 229. Schwartz

333. Managerial Economics (3)
Models of managerial decision making. Emphasis on the application of economic theory to a variety of business problems. Case studies are employed. Prerequisites: Eco 105 and 145 and Math 41 and 44 (or equivalents) or consent of instructor. Moran

334. Labor-Management Relations (3)
An analytical study of the U.S. system of industrial relations, including the evolution of the labor movement, worker choice on the issue of union representation, the process of collective bargaining and the impact of collective bargaining on the management of the firm. Hyclak

335. Labor Economics (3)
The economic analysis of labor markets, with emphasis on labor supply and demand, wage and employment theory, and the economics of unionism and other labor market institutions. Thornton

336. Business and Government (3)
Analysis of government involvement in the private sector. The problems of monopoly, oligopoly, and externalities in production and consumption. Optimum responses to market failure and analysis of the performance of actual government policies. Prerequisite: Eco 105. Munley, Mudambi

337. Transportation and Spatial Economics (3)
The principles of transportation in theory and practice. Transport models and location theories under varying conditions of spatial separation of economic activity. Analysis and evaluation of transportation policies. Prerequisite: Eco 105 or consent of the department chairman. Pillsbury

339. International Trade (3)
The theory of international trade; the theory of tariffs; United States commercial policies; the impact of growth and development of the world economy. Gunter

340. (Fin 340) International Finance (3)
Analysis of balance of payments and disturbances and adjustment in the international economy; international monetary policies. Prerequisite: Eco. 229. Callahan, Gunter

343. European Economic Integration (3)
Analysis of the problems of economic integration with special emphasis on the development of economic cooperation and integration in Western Europe. The methods and the problems of economic planning in the Common Market. United States trade and investments, and European economic integration. Jensen

346. Business Cycles and Forecasting (3)
A study of short-term business fluctuations, growth, forecasting and stabilization. Prerequisite: a course in statistics.

351. Introduction to Mathematical Economics (3)
Application of mathematical techniques to economic problems of optimization and to economic models. Prerequisite: Math 41 and 44, Eco 105 and 119. Taylor, Innes

352. Advanced Statistical Methods (3)
Advanced probability theory, probability and sampling distributions, and classical statistical inference. Index numbers, multiple regession, correlation, and analysis of variance. Spectral analysis, Box-Jenkins auto-regressive and moving average stochastic processes. Prerequisite: a course in statistics. Shen, Taylor

353. (Fin 353) Public Finance: Federal (3)
A course dealing with government expenditures and revenues, the economics of taxation, and government administration. Aronson, Munley

354. (Fin 354) Public Finance: State and Local (3)
The major issues regarding revenues, expenditures, debt and budgeting policy are examined in the light of fiscal principles and economic effects of state and local governments. Special attention is placed on intergovernmental fiscal relations. Aronson, Munley

357. Econometrics (3)
Problems in construction, evaluation and use of econometric models. Applications based on research and case studies. Prerequisite: a course in statistics and a course in intermediate economic theory. King

361. Senior Seminar (3)
Intensive study and discussion of significant topics in economic policy and theory. Prerequisite: Senior standing as economics major or consent of department chairman.

362. Fairchild-Martindale Research Seminar (1-3 hrs.)
This course prepares students to undertake research on various topics in business and/or economics. Admission to this course is limited to student associates of the Fairchild-Martindale Center for the Study of Private Enterprise. Consent of the instructor is required. Course may be repeated for credit up to a maximum total number of 3 hours credit.

371. Readings in Economics (3)
Readings in various fields of economics, designed for the student who has a special interest in some field of economics not covered by the regularly scheduled courses. Prerequisite: preparation in economics acceptable to the department chairman.

372. Readings in Economics (3)
Continuation of Eco 371.

For Graduate Students

401. Basic Statistics for Business and Economics (3)
Descriptive statistics, probability and probability distributions, estimation, hypothesis testing, correlation and regression, chi-square analysis, and analysis of variance. Computer applications. King, Thornton

405. Microeconomic Theory (3)
The role of the price mechanism in the allocation of resources. Emphasis on the behavior of consumers and firms in various market structures. Pricing of the factors of production and the analysis of general equilibrium. Cohen, Munley

409. Money, Banking, and Macroeconomic Analysis (3)
The monetary process and the determination of macroeconomic variables: income, output, employment, and prices. Money and capital markets, interest rates, functions of financial intermediaries, monetary and fiscal policy, and recent macroeconomic issues. Gunter, Schwartz

411. Energy Economics (3)
The economics of energy production and consumption. Energy system modelling for forecasting and planning. Theoretical models of resource exploitation over time. Regulation of the energy industry. Prerequisites: Eco 405 and Mgt 401 or equivalents. McNamara

413. Urban Economics (3)
The application of traditional and spatial economics to the location of economic activity focusing on the urban economic problems of business location, housing, land value, land use and intra-urban transportation. Pillsbury

415. Applied Econometrics (3)
Computer applications of standard econometric techniques using regression analysis in a single equation context. Discussion of problems of multicollinearity, heteroscedasticity and autocorrelation. An introduction to simultaneous equation models, identification and estimation problems. Prerequisite: a course in basic statistics. King

419. Economic History of the United States (3)
Analysis of the colonial economy, transition to industrialization, and role of trade and transportation in America's development. A consideration of the importance of slavery to the 19th century American and other New World economies. Origin and development of banking and financial markets. Prerequisites: intermediate microeconomic theory and basic statistics. Callahan

420. Advanced Macroeconomic Analysis (3)
Macroeconomic theory and policy. Primary emphasis on theoretical models and policy implications. Prerequisite: Eco 119 or equivalent. Innes, Mudambi

421. Managerial Economics (3)
Application of economic analysis to business problems: price and output determination in various markets, analysis of cost and the forecasting of business conditions. Case studies. Prerequisite: Eco 405 and Mgt 401 (or equivalents). McNamara, Moran

432. Advanced Microeconomic Analysis (3)
A survey of methods of decision-making at the microeconomic level; price theory and econometric applications. Prerequisite: Eco 105 or equivalent. Garb

433. (Fin 433) Valuation Seminar (3)
Determinants of financial asset values. The role of uncertainty, imprecise forecasts, risk preferences, inflation, and market conditions. Prerequisite: Fin 411. Beidleman, Buell

434. Government Regulation of Business (3)
Analysis of the economic justification for government regulation of private enterprise. Topics include antitrust policy, utilities, and health, safety and environmental regulation. Prerequisite: a course in intermediate microeconomic theory. Munley

435. Advanced Topics in Microeconomics (3)
Resource allocation and price determination. Theories of choice of consumers, firms and resource owners under various market forms. Prerequisite: Eco 105 and 145 or equivalents. Garb

436. Advanced Topics in Macroeconomics (3)
Models of employment, income, and growth in monetary economies. Policies for economic stability and growth. Prerequisite: Eco 420 or equivalent. Innes

437. Labor Economics (3)
The economics of labor markets and various labor market institutions with emphasis on current theoretical and empirical research. Prerequisite: intermediate microeconomics and statistics. Thornton

438. Labor-Management Administration (3)
A study of the U.S. system of industrial relations, including the evolution and present status of labor law; union organizing efforts; the strategy of negotiations; the substantive provisions of collective bargaining and the administration of collective agreements. Hyclak

439. History of Economic Thought (3)
Selected topics in the history of economic thought, with special attention to the origins of modern economic theory. Prerequisite: a graduate course in economic theory. Cohen, Schwartz

440. Regional Science-Metropolitan Analysis (3)
A study of the methodology of regional science with emphasis on metropolitan area analysis. A survey of the applications of this methodology to the economic problems of regions and metropolitan areas. Pillsbury

442. (Fin 442) Foreign Trade Management (3)
Foreign operations, including export channels in foreign markets, export and import financing, foreign investments, and policies of government and international agencies.

443. Economics of Environmental Management (3)
Economic theory of natural resources. Optimal policies for the development of renewable and nonrenewable resources and environmental quality. Prerequisite: Eco 105 or equivalent and Math 44 or equivalent. McNamara

444. (Fin 444) Banking and Monetary Policy (3)
Analysis of the U.S. monetary and banking systems. Financial markets. Central bank controls, monetary theory and policy. Prerequisite: a course in money and banking. Innes, Schwartz

445. International Trade Theory (3)
Theories of comparative advantage, factor price equalization, trade and welfare, tariffs, trade and factor movements. Prerequisite: Eco 432 or consent of the chairman. Garb, Gunter

446. International Monetary Economics (3)
Theory of the balance of payments, the microeconomics of international finance, various approaches to balance-of-payments adjustments, theories of foreign exchange rate determination and macroeconomic policy under fixed and flexible exchange rates. Prerequisite: Eco 420 or consent of the chairman. Callahan, Gunter

447. (Fin 447) Capital and Interest Theory (3)
Theories of interest and capital. Annuities; applications of present value theory; investment valuation under uncertainty and risk; term structure of interest rates; the theory of savings, cost of capital and capital formation. Prerequisite: a course in finance. Schwartz

449. (Fin 449) Public Finance (3)
The economics of public spending and taxation; principles of government debt management; theories of budgeting and cost-benefit analysis and public choice. Aronson, Munley

451. International Economic Development (3)
An introduction to the basic theoretical concepts in international economic development and an evaluation of their application by means of a representative sample of the literature. Cohen

453. Index Numbers and Time Series Analysis (3)
Classical decomposition of time series, trend analysis, exponential smoothing, spectral analysis and Box-Jenkins autoregressive and moving average methods. Shen

454. Forecasting (3)
Methods of economic and business forecasting. Shen, Taylor

455. Econometric Theory (3)
Mathematical and statistical specification of economic models. Statistical estimation and tests of parameters in single and multiple equation models. Prediction and tests of structural changes. Prerequisites: background in statistics and calculus. Taylor, Shen

456. Mathematical Economics (3)
Applications of various mathematical techniques in the formulation and development of economic concepts and theories. Prerequisite: consent of the department chairman. Taylor, Garb

457. (Fin 457) Monetary Theory (3)
The role of money in the economy from theoretical and empirical perspectives. The influence of money and prices, interest rates, output and employment. Prerequisite: Eco/Fin 444 or equivalent. Innes, Callahan, Gunter

459. (Fin 459) International Financial Economics (3)
Analysis of the structure and functioning of the international monetary system, international capital markets, Eurocurrency markets, fixed and floating exchange rates, and the role of international monetary institutions in foreign exchange risk management. Callahan, Gunter

461. Methodology in Theory and Research (3)
Foundations of theory construction and empirical research in economics. Balabkins, Garb

463. Advanced Statistics for Business and Economics (3)
An expanded development of statistical concepts necessary for business and economic research. Topics include probability theory, sets, density functions and distributions, sampling distributions, point estimation, moment generating functions, maximum likelihood, classical statistical inference, power functions, likelihood ratio tests and non-parametric tests.

Prerequisites: Math 41 and Math 44 or equivalents. Taylor, Shen

465. Topics in Industrial Organization (3)
Theoretical and empirical analysis of how the structure, organization, and behavior of firms and industries affect economic performance and economic welfare. Prerequisite: Eco 405 or equivalent. Mudambi, Garb

471. Special Topics in Economics (3)
Extended study of an approved topic not covered in scheduled courses.

472. Special Topics in Economics (3)
Continuation of Eco 471.

499. Dissertation in Economics and Business

College of Education

Paul VanR. Miller, *Dean.*

The College of Education is organized into two departments and eight program areas. The departments are the Department of Counseling Psychology, School Psychology, and Special Education and the Department of Leadership, Instruction, and Technology.

The department faculties and program offerings are listed below followed by descriptions of course offerings. More details on specific degree requirements and on University Graduate School regulations can be found in the section on Advanced Study and Research.

Department of Counseling Psychology, School Psychology, and Special Education

Professors. Raymond Bell, Ed.D. (Lehigh), *Chairperson;* Andrew J. Edmiston, Ph.D. (Penn State); J. Gary Lutz, Ed.D. (Lehigh); John A. Mierzwa, Ed.D. (Harvard); Paul VanR. Miller, Ph.D. (Pennsylvania); Artis J. Palmo, Ed.D. (West Virginia).

Associate Professors. Diane M. Browder, Ph.D. (Virginia); Edward S. Shapiro, Ph.D. (Pittsburgh); William B. Stafford, Ed.D. (Indiana).

Assistant Professors. F. Charles Mace, Ph.D. (Arizona); Robert J. Suppa, Ed.D. (Kentucky).

Adjunct Faculty. Douglas K. Brown, Ph.D. (Arizona); Ellen N. Cohen, Ph.D. (Columbia); Mary Ann Demchak, M.P.A. (Penn State); Libby Goodman, Ed.D. (Temple); Diane Smallwood, Ph.D. (Rutgers); Mervin P. Smolinsky, Ph.D. (Pittsburgh).

Research Scientist. Barbara West, M.Ed. (Lehigh).

The department offers masters degrees and professional certification in Elementary and Secondary School Counseling, Community Counseling, Special Education and Social Restoration as well as the Ed.S. degree and professional certification in School Psychology. Ed.D. degree programs are offered in Counseling and Special Education and the Ph.D. degree is offered in Counseling Psychology and Psycho-Educational Studies. While general courses in the College are listed separately, the courses pertinent to each program are listed below.

Department of Leadership, Instruction, and Technology

Professors: LeRoy J. Tuscher, Ph.D. (Florida State), *Chairperson;* Alfred J. Castaldi, Ed.D. (Pennsylvania); Fenwick W. English, Ph.D. (Arizona State); Charles W. Guditus, Ed.D. (Lehigh); Joseph P. Kender, Ed.D. (Pennsylvania); Robert L. Leight, Ed.D. (Lehigh); J. Gary Lutz, Ed.D. (Lehigh); Herbert Rubenstein, Ph.D. (Columbia); Perry A. Zirkel, J.D. Ph.D. (Connecticut), LL.M. (Yale), *University Professor of Education and Law.*

Associate Professors: Warren R. Heydenberk, Ed.D. (Colorado); Donald E. Langlois, Ed.D. (Columbia); Richard J. O'Connor, Ed.D. (Louisiana State); Elvin G. Warfel, Ed.D. (Columbia).

Assistant Professor: Francis A. Harvey, Ed.D. (Harvard).

Visiting Assistant Professor: Joseph R. Little, Ed.D. (Lehigh).

Adjunct Faculty: Jack Cassidy, Ph.D. (Temple); Robert J. Kopecek, Ed.D. (SUNY Albany); John D. McAndrew, Ed.D. (Lehigh); James E. Morrell, Ed.D. (Lehigh); Thomas E. Persing, Ed.D. (Lehigh); Arthur L. Scott, Ed.D. (Lehigh); Hilary B. Shuard, M.A. (Oxford); David S. Snyder, Ed.D. (Lehigh); Karol Strelecki, M.Ed. (Lehigh); Stinson W. Stroup, J.D. (Chicago); M. Jerry Weiss, Ed.D. (Columbia).

The department offers masters degrees and professional certification in Elementary and Secondary School Administration, Elementary and Secondary Education, Reading, as well as a master of science degree in Educational Technology. Ed.D. degree programs are offered in Administration and Supervision, Educational Technology, Elementary Education, Foundations of Education, and Reading. While general courses in the College are listed separately, the courses offerings for each program are listed below.

Education

Educ 312. Classroom Practice (1-3)
Experience in elementary and secondary classrooms as related to theories of child and adolescent development, classroom didactics, and philosophies of education. Problem-centered discussion and observations. Prerequisite: consent of the program director.

Educ 313. Intern Teaching (3-6)
Intensive practice in the application of the principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

Educ 314. Seminar in Elementary & Secondary Education (1-3)
Critical analysis and discussion of classroom instructional practices based on experiences of participants as they engage in teaching experiences. Prerequisite: consent of the program director.

Educ 320. (Psyc 320) Psycholingustics (3)
Study of the experimental and observational literature on psychological processes involved in the production, comprehension and use of language by adults.

Educ 321. The Writing Process (3)
Developmental characteristics of childrens' writing and relationships among writing, spelling and reading. Predictors of writing achievement, teaching strategies and activities, and evaluation schemes will be emphasized, K-12.

Educ 330. Study of the Individual (3-6)
Examinations of individual growth and development, especially the patterns found in different subcultures. Prerequisite: consent of the program director.

Educ 341. The Teacher in Social Restoration (3-6)
Functions of the teacher and the school in prevention and remediation of antisocial behavior. Field work in remedial teaching and experience in social restoration institutions. For social restoration interns only.

Educ 343. The Disadvantaged Student (3)
Philosophical analyses of disadvantagement and relevant educational theories. Applications and evaluations of special methods and techniques.

Educ 351. Statistical Methods in Research (3)
Methods of describing and condensing sample data and drawing inferences about population characteristics. No background in statistics presumed. Emphasis on concepts.

Educ 388. Computer Applications (3)
Writing and testing computer programs; use and adaptation of packaged programs; applications in behavorial research, administration, and instruction. Prerequisite: Educ 408, or consent of the program director.

Educ 391,2. Workshops (1-3)
Cooperative study of current educational problems. Provides elementary, secondary, and special education teachers an opportunity to work at their own teaching levels and in their own fields. Limited to six credits during a summer session but the student may register for more than one workshop provided there is no duplication in subject matter.

Educ 394. Special Topics in Education: (with subtitle) (3)
Examination of a topic of research or professional interest in Education. Subtitle will vary. May be repeated for credit as Subtitle varies.

Educ 400. Educational Psychology (3)
An overview of learning theories, human growth and development, and the effect of selected educational practices upon the student. Attention is given to alternative strategies and processes of learning intervention.

Educ 401. Sociological Foundations of Education (3)
The American school as a social institution, its cultural heritage, its purposes and processes in relation to social change and educational leadership; its role in socialization and its responsibilities for relevance to social issues and to subcultural needs.

Educ 402. Methods of Statistical Inference and Research Design (3)
Introduction to packaged programs for computer analysis. Analysis of variance and covariance in experimental designs. Multiple correlation and regression. Prerequisite: Educ 351 or consent of program director.

Educ 403. Research (3)
Basic principles of research; techniques of gathering and analyzing data; design of studies in education. Emphasis on critical reviews of research reports representing various methodologies. Research report required.

Educ 404. Introduction to Testing and Evaluation (3)
Construction and evaluation of the teacher-made test. Selection of published tests and interpretation of individual and group results. Use and misuse of tests in assessing achievement.

Educ 405. Comparative Education (3)
Survey of educational practices abroad from nursery to graduate education. Systems of articulation, social foundations, legal foundations, and structure in government. Nature and purposes of the schools with reference to cultural patterns. Focus upon major problems and trends.

Educ 406. Historical Foundations of Education (3)
Development of primary, secondary, and higher education; aims, curricula, methods, and systems of schooling in America from colonial time to present, in relation to social conditions.

Educ 407. Philosophical Foundations of Education (3)
Comparative philosophical analysis of educational aims, practices, and institutions. Major philosophical theorists whose work has influenced educational thought.

Educ 408. Statistics I (3)
Data reduction, characteristics of frequency distributions, bivariate correlation and regression. Hypothesis testing, interval estimation, errors of inference, statistical power. Normal, t, F, and chi-square sampling distributions.

Educ 409. Statistics II (3)
One-way and factorial analysis of variance and covariance. Multiple correlation and regression, partial and part correlation. Use of packaged programs for computer analysis. Prerequisite: Educ 408 or consent of the program director.

Educ 410. Statistics III (3)
Analysis of variance and covariance in higher-order experimental designs including, factorial, incomplete factorial, nested, and repeated measures. Linear models approach. Prerequisite: consent of the program director.

Educ 411. Multivariate Analysis (3)
Multinormal sampling distribution. Multivariate tests of significance, interval estimation, analysis of variance and covariance. Discriminant analysis, canonical correlation, introduction to factor analysis. Prerequisite: Educ 410 or consent of the program director.

Educ 412. Psychometric Theory (3)
Theory of measurement applied to various kinds of tests and scales. Item analysis; pretesting, scaling and equating; errors of measurement; reliability and validity; prediction. Prerequisite: Educ 408 or consent of the program director.

Educ 413. Intern Teaching (3-6)
Intensive practice in the application of principles of teaching. Supervision is provided by the cooperating school and by the university. Prerequisite: consent of the program director.

Educ 414. Intern Teaching Seminar (3)
Critical analysis and discussion of classroom instructional practices. Discussion and illustration based on experience of participants as they engage in intern teaching. Prerequisite: consent of the program director.

Educ 415. Classroom Didactics (3)
Initial preparation of interns for classroom teaching. Secondary interns are trained in teaching methods in subject fields and the reading problems of secondary students. Elementary interns study teaching methods in the elementary school. Open to teaching interns only.

Educ 416. (SR 416) Quasi-Experimentation & Program Evaluation (3)
Social science research methods for non laboratory settings. Detailed examination of a dozen quasi-experimental research designs, three dozen threats to validity, possible controls, and uses in social program evaluation. Non-mathematical presentation.

Educ 417. Participation in Teaching (3)
Study, directed observation of, and initial practice in the various phases of teaching in a laboratory-demonstration school or in area elementary and secondary schools. Prerequisite: consent of the program director.

Educ 418. Science in Elementary Education (3)
Principles of the elementary science program. Demonstrations and discussions of appropriate materials and techniques for teaching science concepts to elementary school students.

Educ 419. Mathematics in Elementary Education (3)
Mathematical skills and concepts for the elementary school program. Sets, systems of numeration, experience with numbers, operations with numbers, number concepts and numerals, and elements of geometry.

Educ 420. Linguistics in Education (3)
The nature of language, phonetic applications and the relationships of linguistics to instruction in the language arts.

Educ 421. Materials in Reading (3)
Provides examination and critical analysis of published and unpublished reading materials used in instruction from kindergarten through adult levels. Prerequisite: Educ 426 or consent of the program director.

Educ 422. Language Development of Children (3)
The nature of language and its relation to the development of communication skills. Critical analysis of related research. Implications for the elementary school.

Educ 423. Social Studies in Elementary Education (3)
Curriculum, content, teaching strategies, and instructional materials of the social studies field. Emphasis will be placed on organizing content, using appropriate methods, testing and evaluation, and innovations for social studies in the elementary school. Some attention will be given to examining textbooks, courses of study, and teacher-made materials.

Educ 424. Developmental Reading (3)
Introductory course spanning the elementary and secondary levels. Reading methods, materials, the disadvantaged and gifted reader, procedures for individualized reading instruction. Field experience required.

Educ 425. Fine Arts in Elementary Education (3)
Techniques for the infusion of concepts, skills and understandings from the creative arts into the elementary school program.

Educ 426. Diagnosis & Adjustment of Reading Difficulties (6)
Psychology of reading related to learning difficulties; measurement and diagnosis of reading difficulties; development of informal tests; materials for corrective and/or remedial instruction. Prerequisite: Educ 424 or consent of the program director.

Educ 427. Children's Literature in Reading Instruction (3)
Role of literature in the instructional program of the elementary schools. Use of trade books for individual instruction in reading.

Educ 428. Reading in the Content Areas (3)
Focuses on expository reading development in content areas such as language arts, mathematics, science and social studies. Practical teaching strategies in critical areas, such as comprehension and study skills. Review of research and methods for improving the reading development of students.

Educ 429. Child Development (3)
A study of physical, intellectual, emotional and social aspects of child development as they relate to the elementary schools.

Educ 430. Advanced Topics in Reading (3)
Theory and research in historical background of reading instruction; cognitive, affective, and linguistic aspects of reading; implications for the disadvantaged and gifted reader. Field experience required. Prerequisite: Educ 424 or consent of the program director.

Educ 432. Reading Specialists Clinic (6)
Concentrates on diagnosis of reading problems and disabilities and the remediation of the deficits in children. Requires the graduate student to work with reading-disabled children for 125 clock hours.

Educ 434. Seminar in Reading Research (3)
An advanced course dealing with critical appraisal and discussion of classical and current studies in reading.

Educ 436. Practicum in Supervision of Reading Program (3)
For candidates for supervisor's certificate in reading. Organization of the instructional processes in reading programs. Participants in supervisory activities.

Educ 438. Programs for Gifted & Talented (3)
Characteristics of gifted children; teaching gifted children; programs for the gifted in elementary and secondary schools.

Educ 441. Youth in Society (3)
Social development, characteristics, and problems of adolescents and young adults. Impact of relationships with sibling, peers, adults, subcultures, in the context of changing institutions and values.

Educ 450. Foundations of Curriculum Construction (3)
Principles of organization of programs of studies for elementary and secondary schools; origin and background of the curriculum; methods of organization; curriculum planning and development; pertinent applications. K-12.

Educ 451. (Psyc 451) Theories of Learning (3)
In-depth study of major classical and contemporary learning theories. Review of experimental research relevant to theories.

Educ 452. The Elementary School Curriculum (3)
Problems of curriculum development in the first six grades; subject matter placement, program making for difficult types of schools, regular vs. special subjects, articulation.

Educ 454. The Secondary School Curriculum (3)
Methods of study of curriculum problems, selection of subject matter in various fields, principles of program construction, and similar problems.

Educ 460. Program Evaluation (3)
The historical background, theory, methodology, and current practices of program evaluation in the human services area. Emphasis will be placed on conducting evaluations of educational programs. Current research will be conducted and an examination of on-going program evaluations will be conducted.

Educ 461. Single-Subject Research Design (3)
Experimental designs for use with small N's. Topics include design theory and application, experimental validity (internal, external, statistical conclusions and construct validity) and an overview of data analysis procedures.

Educ 474. (Psyc 474) Psychological Development in Childhood (3)
Topics selected from such areas as socialization and the parent-child interaction, personality disorders in childhood, moral development and cognitive development. May be repeated for credit.

Educ 491,2. Advanced Seminars: (with subtitle) (3)
Intensive study and discussion of a specialized area. Title will vary. May be repeated for credit as title varies.

Educ 493. Internship in: (with subtitle) (3)
Opportunity for advanced students to obtain practical experience. Conference hours for students and staff members devoted to discussion of work and problems encountered in the schools. Prerequisite: consent of the program director.

Educ 494. Field Work in: (with subtitle) (3)
Identification of significant problems in an educational environment, review of the literature, and development of appropriate research plans.

Educ 495. Independent Study in: (with subtitle) (1-6)
Individual or small group study in the field of specialization. Approved and supervised by the major adviser. May be repeated.

Educ 496. Doctoral Research Seminar (3)
For doctoral students. Research design and application to various kinds of educational problems; data collection and analysis. Criticism and evaluation of student proposals. May be repeated for a maximum of nine credits.

Administration and Supervision

For Graduate Students

AdmS 400. Educational Administration: Theory and Practice (3)
Development of theories of administration and applications in educational institutions. Administrative behavior in organizational settings; administrator's leadership role in decision-making, evaluation, and conflict resolution.

AdmS 402. Elementary School Administration (3)
Major problems of organization and administration of elementary schools; types of organization, pupil promotion, time allotment, service agencies, and plant equipment.

AdmS 404. Secondary School Administration (3)
Major problems of organization and administration of secondary schools; program of studies, teaching staff, pupil personnel, plant and equipment, and community relationships.

AdmS 406. School Principals Clinic (3-6)
Simulated materials workshop on administrative decision-making open to practicing and prospective elementary and secondary school administrators.

AdmS 410. Administration of Higher Education (3)
Analysis of legal foundations, administrative controls, and operational patterns of various types of institutions of higher education.

AdmS 411. Contemporary Issues in Administration (3)
Analysis of the theoretical, empirical, and conceptual aspects of contemporary issues in educational administration and their implications for policy formulation and implementation in educational institutions. Prerequisite: Permission of the instructor.

AdmS 412. Computer Applications in School Administration (3)
Hands-on experience with computer applications useful in the administration of schools. Applications will include work processing, data base management, financial and demographic forecasting, resource allocation, graphical representation of data, and data retrieval and reporting systems useful for administrative decision making.

AdmS 457. Performance Appraisal (3)
Essential elements for the evaluation of school teachers, principals and superintendents. Research-based constructs as well as practical applications. The course is intended primarily for future and practicing school administrators.

AdmS 466. Supervision of Instruction (3)
Analysis of the principles underlying the organization and supervision of instruction; application to specific teaching situations. K-12

AdmS 467. Management Seminar for Supervisors (3)
A seminar on organization and management for first-line instructional supervisors. Covers four areas, including the legal aspects of supervision, budget development, evaluation, and organization behavior.

AdmS 469. Advanced Instructional Supervision (3)
A staff development approach to supervision designed to extend the supervisor's knowledge of and skills in applying clinical techniques to instructional supervision.

AdmS 473. Personnel Administration (3)
Overview of the personnel function in educational institutions. Trends in staff planning, recruitment, selection, assignment, and orientation, as well as tenure, grievances and related matters.

AdmS 474. Planning for Facility Use (3)
Focus on long-range planning with emphasis on data collection and analysis involved in closing, modifying and/or establishing alternative uses for school facilities. Simulations and field applications are provided.

AdmS 476. School Finance (3)
Concepts of school finance including intergovernmental fiscal relations, state grants-in-aid, taxation, municipal borrowing, and long-term capital outlay programs.

AdmS 477. Seminar in School-Community Relations (3)
Analysis and development of the communication and public relations skills needed by educators in dealing with the public.

AdmS 478. Collective Bargaining in the Schools (3)
Contract negotiations, grievance, mediation, and arbitration for both professional and classified employees in education.

AdmS 479. School Law (3)
Effect of school law on administration of public school systems; analysis and synthesis of judicial interpretations of the constitutions, statutes, rules, regulations, and common law relating to educational issues.

AdmS 480. Administration of Student Service in Higher Education (3)
Administration of student services in higher education including welfare, control, activities, and teaching functions. Organization and operation; administrator's role in development and implementation of appropriate policies.

AdmS 481. Policy and Politics in Public Education (3)
Analysis of the forces, factors, agencies, formal governmental systems and informal subsystems that influence educational policy in local districts and state and national governments.

Counseling

Coun 427. Standardized Tests & Measurements in Counseling (3)
Principles of psychological measurements utilizing assessment techniques with focus upon standard group and individual tests. Administration and interpretation of tests. Prerequisite: Educ 404.

Coun 430. Philosophy and Principles of Counseling (3)
Theoretical foundations, principles, and legal and ethical aspects of counseling. The organization, function, and services of a counseling program are examined. Accountability, counseling the culturally different, use of standardized tests, and other current issues are considered.

Coun 433. Community Psychology (3)
Community agencies are examined through readings, lectures and student presentations. Field investigation of a community counseling agency. Professional ethics, legal issues, accountability and organizational structure of agencies.

Coun 436. Career Development (3)
Examination of the career development process for children, adolescents, and adults. Study of theorists, vocational assessment process, and occupational and psychological information systems.

Coun 439. Theory & Practice of Group Counseling (3)
Introduction to the process of group counseling and therapy. Selection of group members; group rules; group procedures with children, adolescents and adults; ethical considerations with groups. Study of research on group processes, group therapy, and group leadership.

Coun 440. Introduction to Family Counseling (3)
Research and current trends in the practice of family counseling. Overview and analysis of major theoretical approaches of family therapy.

Coun 442. Counseling & Therapeutic Approaches (3)
Introduction to theories and techniques of counseling and therapy. Students will practice therapeutic skills through role play and sessions with clients. Audio and video recordings required. Prerequisites: Coun 430 or Coun 433 or permission of instructor.

Coun 445. Elementary School Counseling & Guidance (3)
Emphasizes professional concerns of the elementary school counselor in working with teachers, parents, administrators, and other specialists. Policies, practices, and curriculum concerns, as they affect the development of the child. Prerequisite: Coun 430.

Coun 448. Secondary School Counseling & Guidance (3)
Establishing an effective secondary counseling and guidance program within the framework of the school setting. Policies, procedures, and curriculum concerns as they affect the student. Professional approaches to involve students, teachers, administrators, and parents in the counseling and guidance activities of the secondary school. Prerequisite: Coun 430.

Coun 451. Group Counseling & Group Processes (3)
Group processes as related to counseling and therapy through group participation and demonstration. Prerequisites: Coun 442 previously or concurrently; Coun 439.

Coun 454. Biofeedback in Counseling (3)
Theory and practice in biofeedback techniques; experience in using biofeedback instruments. Special attention is paid to relaxation procedures, anxiety reduction, and behavioral medicine. Prerequisite: Coun 442.

Coun 457. (Psyc 473) Personality and Adjustment (3)
Theories of personality and adjustment with emphasis on the adjustment processes in an educational setting. Prerequisite: consent of the program director.

Coun 460. (Psyc 475) Theories of Psychological Counseling (3)
Analysis and synthesis of concepts drawn from counseling theorists. Research and current trends in counseling concerning educational, social and vocational problems. Prerequisite: admission to the program in counseling.

Coun 466. Current Issues in Counseling & Therapy (1-6)
Examination of an area of counseling or therapy that is of topical interest to students and faculty. Permission of program director required. May be repeated for credit.

Coun 470. Independent Study & Research (1-6)
Individual or small group study in the field of counseling. Approved and supervised by the major adviser. May be repeated for credit.

Coun 473. Research Seminar in Counseling (3-9)
For doctoral students in counseling. Research design, data collection, and data analysis. Criticism and evaluation of student proposals. May be repeated for a maximum of nine credits.

Coun 476. Supervision of Counseling (1-6)
For candidates for supervisor's certificate or doctorate in counseling. Observation and supervision of counseling practicum students. Prerequisites: Coun 480 and permission of instructor.

Coun 478. Advanced Group Leadership (1-6)
Practicum training in group leadership in a counseling or therapeutic setting. Prerequisites: Coun 439, Coun 451, Coun 480 and permission of instructor.

Coun 480. Counseling Internship (3-9)
Supervised practicum training for advanced graduate students in individual, group, and family counseling and therapy. Prerequisites: Coun 442, Coun 451, and permission of instructor.

Coun 483. Field Work in Counseling (3-6)
Identification of significant counseling and therapy related problems in an agency or institutional environment. Review of literature and development of appropriate research plans.

Coun 486. Family Counseling Clinic (3-6)
Supervised practicum training for advanced graduate students in family counseling and therapy. Techniques and methods of conducting family counseling and therapy. Prerequisites: Coun 480 and Coun 440.

Coun 489. Advanced Counseling Clinic (6-12)
Supervised experience in counseling and therapeutic settings for advanced graduate students. Utilization of audio and video recordings, small group supervision, and individual supervision. May be repeated for credit. Permission of instructor.

Educational Technology

EdT 311. (CSc 311) Instructional Programming in BASIC (3)
Introduction to microcomputers and their applications in educational settings. Special emphasis on a structured approach to programming in the BASIC language and on application of principles of instructional design to the development of microcomputer-based instructional materials. No prior experience with microcomputers or programming is assumed.

EdT 313. (CSc 11) Instructional Programming in PASCAL (3)
PASCAL for microcomputers. High level, structured, procedure-oriented languages are examined. Special emphasis on use of structured programming for designing instructional software. Students electing EdT 313 are expected to complete the same course requirements as students taking CSc 11. In addition, they are required to become familiar with a microcomputer disk operating system. This is achieved through course assignments requiring the use of a microcomputer. The additional course requirements add an extra hour per week to the student workload.

EdT 315. (CSc 230) Elementary Artificial Intelligence Applications (3)
How computers play chess, compose music, create prose, simulate psychiatrists, and make medical diagnosis (an illustration of expert systems).

EdT 331. Human Information Processing (3)
Study of the processes involved in perception, learning, problem solving and decision making. Applications of task analysis and artificial intelligence to the design of learning system.

EdT 351. (CSc 351) Cognitive Science (3)
A synthesis of elements of artificial intelligence, psychology and linguistics; concerned with models of the acquisition, representation, storage, retrieval and application of knowledge.

EdT 415. Advanced Instructional Programming in BASIC (3)
Advanced features of BASIC such as sequential and direct-access files, sorting, searching, modeling and simulation. Emphasis on applications in instructional settings. Prerequisite: EdT 311.

EdT 417. (CSc 217) Advanced Instructional Programming in PASCAL (3)
A continuaiton of structured programming in PASCAL. Special emphasis on the application of sound, color, and graphics in instructional courseware development. Prerequisite: EdT 313.

EdT 419. (CSc 211) Computer Organization (3)
Covers all aspects of programming microprocessors from basic concepts to advanced data structures. Additional topics will

include hardware organization, instruction sets, addressing techniques, input/output devices, and application examples. Prerequisites: one high level programming language course (BASIC, FORTRAN, PASCAL, etc.) and consent of program director.

EdT 420. Media Production for Instructional Programming (3)
Applications in the design, production, editing, and evaluation of educational video tapes. Students will gain hands-on experience designing, filming, editing, and producing educational learning materials in a studio production center.

EdT 421. Computer Literacy (3)
An analysis of microcomputer applications designed for use in education and training. Special emphasis is placed on microcomputer applications. Hands-on experience in a microcomputer laboratory.

EdT 423. Instructional Programming in LOGO (3)
Hands-on experience with LOGO as a programming language and a philosophy of education. Study of turtle geometry procedures, recursion, words and lists, hierarchical structures, and interactive programming. Case studies of LOGO applications in various settings and with various computer systems.

EdT 425. Learning, Technology and Society (3)
A general survey of the impact of educational technology on modern society. Special attention to the use of large-scale data banks and retrieval systems, problems of privacy, impact of automation on everyday life, and effects of the new learning technologies on curriculum development and education configurations.

EdT 427. Educational Technology and Instructional Games and Simulations (3)
An examination of the motivational, technical, and instructional issues related to the design of microcomputer/video educational games and simulations. Course requirements will include designing and programming an instructional game or simulation. Prerequisite: EdT 429.

EdT 429. Instructional Programming in Assembly Language (3)
Translation of arithmetic and logical problems related to the use of sound, graphics, and animation into forms permitting their solution by microcomputers through assembly language programming. Emphasis on applications in instructional settings.

EdT 433. Instructional Systems Design (3)
The theory and process of developing and producing instructional units. Essentials for the production of instructional components that can be used directly in the development of microprocessor-controlled instructional units.

EdT 435. Interactive Learning (3)
Introduction to the utilization of interactive television, video-disc technology, *CD-ROM* and other high technologies for producing instructional software.

EdT 436. Advanced Programming and Applications in Logo (3)
Advanced programming in Logo, with special emphasis on interactive programs, recursion, and advanced use of lists (for example, association lists and manipulating programs as data). Analysis of current practices and issues related to Logo in education. Prerequisite: EdT 423 or equivalent.

EdT 443. (CSc 343) Microcomputer-Aided Instruction (3)
Design and development of microcomputer-assisted instructional units. Students design, program and test microcomputer-aided instructional units as a drill, practice, tutorial, and simulation exercises.

EdT 471. Evaluation of Technology-Based Instructional Systems (3)
Examination of current issues and practices related to the design and evaluation of instructional system with special consideration to the delivery and management of instruction utilizing educational technology. A case study approach will be used to study both Instructional Systems and the evaluation of individual learning in technology-based curricula.

EdT 477. Research Topics in Educational Technology (3)
Examination of current issues and practices related to the field of educational technology. Topics will vary (e.g., The Role of Educational Technology in Teaching Persons with Special Needs; The Role of Educational Technology in Teaching Preschool/Nursery School Children; Educational Implications of Sound and Graphics. May be repeated for credit as topic varies.

School Psychology

SchP 402. (SpEd 402) Behavior Modification (3)
Theory and application of behavior modification methods in classroom and clinical settings. Topics include behavior analysis, outcome research, task utilization, and single case research.

SchP 404. Professional Issues in School Psychology (3)
Role of the school psychologist, emphasis upon consultation. Legal aspects of school psychology. Prerequisite: admission to the school psychology program.

SchP 405. Standardized Educational Assessment (3)
Educational assessment procedures used with exceptional individuals. Understanding and applying information from formal education assessment and interviews.

SchP 412. Consultation Procedures (3)
Observational methodology utilized in consultation; rationale, theory and methods of consultation; individual, group and parent consulting. Study of research on the consultation process.

SchP 422. Assessment of Intelligence (3)
Practice in the administration of individual tests of intelligence used in school evaluations and preparation of psychological reports. Prerequisite: permission of instructor.

SchP 423. Assessment of Behavior (3)
Techniques of behavioral assessment including, direct observation, interviews, checklists, rating scales, self-monitoring and role-play tests. Prerequisite: permission of instructor.

SchP 424. Assessment of Personality (3)
Practice in the administration of instruments used for personality assessment. Supervised experience and report writing. Prerequisites: Educ 404 and SchP 422.

SchP 425. Assessment & Intervention in Educational Consultation (3)
Collection and use of data in designing classroom interventions. Curriculum based assessment, direct behavioral assessment, and structured interviews, and the interrelationship with diagnoses are emphasized within the behavioral consultation model. Utilization of data from actual case studies. Prerequisites: SchP 402, 423.

SchP 426. Advanced Child Behavior Therapy (3)
Techniques of child behavior therapy applied in classrooms and clinical settings. Particular emphasis on self-control procedures, such as social skills training, self-instruction training, and cognitive behavior therapy. Course covers both the theoretical and practical components of procedures. Prerequisite: SchP 402.

SchP 428. Advanced Behavior Management in Developmental Disabilities (3)
This course will develop skills in long-term remediation of behavior problems characteristic of severely developmentally disabled individuals through functional analysis and management of variables influencing behavior.

SchP 430. Doctoral Seminar in School Psychology (with subtitle) (1-3)
Selected topics in school psychology (titles will vary) including professional issues, assessment and intervention in school settings, and supervision of school psychology services. May be repeated for credit. Prerequisite: admission to doctoral program.

SchP 434. (SpEd 434) Applied Research Practicum (1-3)
Designing and conducting research projects in applied settings.

SchP 442. School Psychology Practicum (1-6)
Experience in conducting assessments, designing interventions, and/or consultation. Taken in association with SchP 412, SchP 423, & SchP 425.

SchP 443. Clinic Internship (3)
Experience in clinic/educational setting. Student must complete 300 clock hours under faculty supervision at the University laboratory school and/or other clinical/educational setting.

SchP 444. Field Internship (6)
Full-time experience in educational settings. Student must complete 1,000 clock hours in an appropriate educational setting (25 weeks) under joint supervision of faculty and field supervisor.

Special Education

SpEd 330. Special Topics in Special Education: (with subtitle) (1-3)
Current issues in the education of handicapped individuals. Titles vary. May be repeated for credit as title varies.

SpEd 331. (Psyc 352) Emotional and Behavioral Disorders of Children (3)
Definition, classification, etiology, treatment, and historical perspective of children and adolescent disorders.

SpEd 332. Education of Exceptional Children (3)
Curriculum, methods of instruction, and materials for individuals who differ markedly from the normal intellectually, physically, emotionally, or socially; the nature and causes of these differences; available resources. Field trips, direct work with exceptional children encouraged.

SpEd 333. Developmental Disabilities (3)
Definition, classification, etiology, treatment and historical perspectives of individuals with mental retardation, autism, cerebral palsy, and other developmental disabilities (e.g., deaf/blind).

SpEd 339. Learning Disabilities (3)
Definition, classification, etiology, treatment, and historical perspective of individuals with learning disabilities.

SpEd 402. (SchP 402, Psyc 402) Behavior Modification (3)
Theory and application of behavior modification methods in classroom and clinical settings. Topics include behavior analysis, outcome research, task utilization, and single case research.

SpEd 415. Motor Skills for Handicapped Individuals (3)
Remediation of movement difficulties. Emphasis on teaching physically handicapped individuals.

SpEd 417. Language and Social Skills for Handicapped Children (3)
Atypical language and social development of handicapped children. Particular emphasis upon the development of a direct implementation of field programs.

SpEd 418. Teaching Severely Multihandicapped Individuals (3)
Instructional emphasis upon areas of daily living and functional academics. Emphasis on training handicapped individuals to live in the least restrictive environment.

SpEd 419. Teaching Mildly Handicapped Individuals (3)
Instructional emphasis upon specialized curricula and methods for teaching typical school subjects. Emphasis on training handicapped individuals to learn in the least restrictive environment.

SpEd 420. Intern Teaching: Certification (3)
Competency based practice in application of procedures for teaching a broad spectrum of handicapped individuals in preparation for Level 1 Certification as a Teacher of the Mentally or Physically Handicapped. Prerequisite: consent of program coordinator one semester before registering for this course.

SpEd 423. Programmatic Intervention with Emotionally Disturbed Students (3)
Theoretical and applied facts of structured treatment. Emphasis on the etiology and structure of the engineered classroom within a ReEducation model that promotes positive academic and social behaviors.

SpEd 424. Assessment of Severely Handicapped Individuals (3)
Curriculum based assessment and program development for individuals whose handicaps preclude traditional academic or psychological assessment. Emphasis on life skills assessment.

SpEd 425. Specialization Internship (3)
Competency based practice to develop specific expertise in Behavior Disorders, Severe/Multihandicaps, Curriculum and Consultation or Special Education Technology. May be repeated for credit in more than one specialty.

SpEd 430. Advanced Seminar in Special Education (3)
Advanced issues relating to the field of special education. Titles will vary.

SpEd 432. Supervision of Special Education (3)
Advanced knowledge of teaching research with handicapped individuals. Teacher supervision models.

SpEd 434. (SchP 434) Applied Research Practicum (1-3)
Designing and conducting research projects in applied settings.

SpEd 435. Internship: Supervision of Special Education (3)
Advanced students receive competency based practice in staff supervision in preparation for certification as a Supervisor of Special Education. Prerequisite: consent of program coordinator one semester before registering for the course.

SpEd 490. Doctoral Seminar in Special Education (3)
Advanced knowledge of issues and research in the education of handicapped individuals. Topics will vary. May be repeated for credit. Prerequisite: admitted for doctoral studies.

Educational Technology

See listings under Education.

Electrical Engineering

See listings under Computer Science and Electrical Engineering.

Electrical Engineering and Engineering Physics

This curriculum is particularly well suited for students seeking thorough preparation in the field of electronic device physics. The program adds to the basic electrical engineering curriculum a sequence of upper-level undergraduate physics courses.

The electrical engineering degree is conferred upon the completion of the fourth year (133 credit hours), and the engineering physics degree at the end of the fifth year (165 credit hours). Both are bachelor of science degrees. Interested students should contact Shelden H. Radin, department of physics, for information:

freshman year in engineering (see page 36)

sophomore year, first semester (17 credit hours)

ECE 81	Principles of Electrical Engineering (4)
CSc 33	Principles of Computer Engineering (4)
Math 23	Analytic Geometry and Calculus III (4)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)

sophomore year, second semester (17 credit hours)

ECE 108	Signals and Systems (4)
Math 205	Linear Methods (3)
Phys 31	Introduction to Quantum Mechanics (3)
Eco 1	Economics (4)
	general studies (3)

junior year, first semester (17 credit hours)

ECE 123	Electronic Circuits (3)
ECE 121	Electronic Circuits Laboratory (2)
ECE 125	Circuits and Systems (3)
Math 231	Probability and Statistics (3) **or**
Math 309	Theory of Probability (3)
Phys 212	Electricity and Magnetism I (3)
	general studies (3)

junior year, second semester (16 credit hours)

ECE 126	Physical Electronics (3)
ECE 136	Electromechanics Laboratory (3)
ECE 138	Digital Systems Laboratory (2)
Phys 213	Electricity and Magnetism II (3)
	mathematics elective (3)
	free elective (3)

senior year, first semester (18 credit hours)

ECE 111	Proseminar (1)
ECE 151	Senior Laboratory I (2)
Phys 215	Classical Mechanics I (3)
ECE	departmental elective (3)
	general studies (3)
	free electives (6)

senior year, second semester (18 credit hours)

Phys 362	Atomic and Molecular Structure (3)
Phys 264	Nuclear and Elementary Particle Physics (3)
ECE	departmental electives (9)
	general studies (3)

fifth year, first semester (17 credit hours)

Phys 216	Classical Mechanics II (3)
Phys 273	Research (2-3) **or**
Phys 260	Laboratory Techniques (2)
Phys 340	Thermal Physics (3)
Math 322	Methods of Applied Analysis I (3)
	approved elective** (3)
	free elective (3)

fifth year, second semester (15 credit hours)

Phys 261	Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phys 171	Physics Proseminar (1)
	approved electives** (3)
	free electives (6)

**Approved electives include two courses selected from Phys 363, 367, 369, 352 or 355, and 346 or 348 or 365. Students planning graduate work in physics are advised to include Phys 273 and 369 among their electives.

Engineering

Engr 1 is required of all engineering and applied science majors and is taken in the recommended freshman year.

1. Engineering Computations (3) fall-spring
Introduction to the solution of engineering problems through the use of the computer. Elementary computer programming in FORTRAN is taught and illustrated by means of several topics in computational mathematics such as roots of equations, matrices, least squares analysis, numerical integration, and others. No previous knowledge of computer programming is assumed. Also, a series of lectures and demonstrations are given, outlining the career opportunities available in the various disciplines represented in the College of Engineering and Applied Science. Prerequisite: Math 21 or 31, previously or concurrently.

250. Computer Modeling of Scientific and Engineering Systems (3)
Introduction to the mathematical modeling of scientific engineering systems, with emphasis on higher-order nonlinear models for which analytical methods are precluded. Solution of the model equations by computer-based numerical algorithms. Introduction to numerical methods for linear and nonlinear algebraic systems, ordinary and partial differential equations. Error analysis and control, stability and convergence in numerical calculations. Prerequisites: Engr 1; Math 205, previously or concurrently. Schiesser

Engineering-M.B.A. Program

The bachelor in engineering-master of business administration two-degree program is designed to meet the needs of especially competent students in any engineering curriculum who want to add to their engineering studies training in business management at an advanced level.

The time involved will vary depending on the student's background. One or more summer sessions in addition to two or more regular semesters of study may be necessary after completion of the bachelor's degree in engineering to attain the M.B.A. or M.S. in management science. Candidates take the Graduate Management Admission Test and must meet the standards for admission into The Graduate School.

For background courses required for the master of business administration program, engineering students should read Section IV, Graduate Study in Business and Economics, and consult with Joseph P. Klein, assistant dean of the College of Business and Economics.

Engineering Mathematics Courses

See listings under Mechanical Engineering and Mechanics.

English

Professors. Frank S. Hook, Ph.D. (Yale), *chairperson;* Rosemarie A. Arbur, Ph.D. (Illinois); Peter G. Beidler, Ph.D. (Lehigh), *Lucy G. Moses Distinguished Professor;* Jack A. DeBellis, Ph.D. (U.C.L.A.); James R. Frakes, Ph.D. (Pennsylvania), *Edmund W. Fairchild Professor of American Studies;* Edward J. Gallagher, Ph.D. (Notre Dame); David M. Greene, Ph.D. (Berkeley); Albert E. Hartung, Ph.D. (Lehigh), *Distinguished Professor;* John W. Hunt, Ph.D. (Chicago), *dean of the College of Arts and Science;* Rosemary J. Mundhenk, Ph.D. (U.C.L.A.); Barbara H. Traister, Ph.D. (Yale); John F. Vickrey, Ph.D. (Indiana).
Associate Professors. Addison C. Bross, Ph.D. (Louisiana State); Jan S. Fergus, Ph.D. (C.U.N.Y.); Elizabeth N. Fifer, Ph.D. (Michigan); Robert R. Harson, Ph.D. (Ohio).
Assistant professors. Alexander M. Doty, Ph.D. (Illinois); Edward E. Lotto, Ph.D. (Indiana), *head of Learning Center.*

The Department of English offers majors in literature and theater. Speech and Theater is a division of the department. For information about its program and course offerings, consult the separate listing in this section of the catalog.

Courses in English language and literature may be considered a general preparation for any decent kind of living. These courses require close attention to words and at the same time encourage that loving respect for the true naming of things, which is the source of all clear and honest thought.

In literature itself, which is words that we wish to hear again and yet again, we may find a happy companionship with minds that can help our own grow straight with grace and understanding. A head that is full of poetry is a good one to live with.

Undergraduate Major in English

The major in English is designed to give interested students experience in reading, analyzing, and formulating thoughts about what Matthew Arnold called "the best that has been thought and said"; an understanding of how literary artists find the appropriate words to express their thoughts and feelings; and a basic knowledge of the historical development of British and American literature.

Students who major in English often go on to careers in teaching, writing, law, or business, but the analytical and communication skills acquired in the study of literature and writing will be of use in almost any profession or human activity. Depending on their interests, abilities, and career plans, students who major in English are encouraged to consider double majors or minors in other fields. The major in English is flexible enough to allow cross-disciplinary study with ease.

The student majoring in English has considerable freedom to choose from an extensive list of courses. To insure breadth of coverage, each major is required to take Engl 25 and 26, British Literature, and Engl 23, American Literature, first semester. These three courses are designed to acquaint the student with the important British and American writers, and with certain movements and trends in literature before the twentieth century.

To insure depth of understanding of at least two basic early writers, each English major is required to take either Engl 329 or 330, Shakespeare and Elizabethan Drama, and either Engl 327, Chaucer, or Engl 331, Milton. In addition to these five courses, each English major elects five additional courses in either English or American literature, at least two of which are in literature before 1900 and at least three of which are numbered above 300.

It should be emphasized that thirty is the *minimum* number of hours for the major; many English majors will elect to take more. Each English major has a departmental adviser to assist in selecting courses for the major program.

The department strongly recommends that any student contemplating the possibility of advanced study of English or American literature or of becoming a teacher of English should work toward departmental honors.

In order to receive departmental honors the English major must attain a 3.50 grade average in courses presented for the major and must complete 39 hours of course work in English. Fifteen of these hours (five courses) are those required for the regular English major: Engl 23, 25 and 26, Engl 329 or 330, and Engl 327 or 331. Twelve hours (four courses) should be chosen from among the department's advanced period courses (Engl 360, 362, 364, 367, 369, 371, 376, 377, 378, 379, 380, 385 and 386), at least two of which must be in literature before 1900; three hours (Engl 181) are in the form of a thesis of substantial length (normally 25 to 50 pages).

The department also recommends that students working for departmental honors elect Engl 248, Introduction to the English Language; that they develop a competency in at least one foreign language; and that they consider petitioning in their senior year to take one of the department's graduate seminars at the 400 level. Students who complete the courses required for departmental honors but who do not achieve the necessary grade-point average will receive the bachelor of arts degree with a major in English.

Minors in English

The Department of English offers three minors, each requiring fifteen hours of course work beyond freshman English. For a minor in British Literature, a student takes Engl 25 and 26, British Literature, and an additional nine hours in British literature, at least six of them in British literature at the 300 level.

To minor in American Literature, a student takes Engl 23 and 24, American Literature, and an additional nine hours in American literature, at least six of them in American literature at the 300 level.

To minor in writing, a student takes Engl 171 and 172, Practical Writing, and Engl 348, Theory and Practice of Writing, and six hours chosen from Engl 73, Engl 201, 248, 281, Journ 315, or any literature course designated Writing Intensive (WI).

The student's major adviser monitors the minor program, but the student should consult the minor adviser in the Department of English when setting up a minor program.

Graduate Work in English

The objective of the graduate program in English is not simply to impart knowledge, however wide or deep, but also to instruct the student in the methods of pursuing advanced study of literature and to provide training in the techniques of criticism and research, and in pedagogical approaches to literature.

A primary aim of the program is to furnish course work and individual instruction suitable for teachers of English at the secondary and college levels. Advanced degrees may be obtained in all areas of English and American literature. In 1985-86 about fifty candidates were enrolled in the graduate programs in English.

Students who wish to enter the graduate program in English should have an undergraduate major in English with at least fifteen credit hours of advanced courses in English literature. Students who did not major in English may be admitted, but will be expected to make up deficiencies in their undergraduate training in English in addition to satisfying other minimum requirements for the graduate degree sought.

Candidates for the master's degrees in English who expect to continue for the doctor of philosophy degree are required to complete successfully twenty-seven credit hours of course work and to write a thesis representing the equivalent of three hours of course work. Master's degree candidates who do not wish to continue for the Ph.D. may, as an alternative, complete successfully twenty-seven hours of course work and pass an examination, preparation for which represents the equivalent of three hours of course work (see Engl 495). Details concerning the examination are available from the graduate program coordinator.

Candidates for the master's degree whose needs and interests make it desirable may substitute up to six hours of collateral work in other departments. Master's candidates must take at least half of their required courses in 400-level

seminars, but may select the balance of their curriculum from a variety of 300-level course offerings. At least six hours of course work for the master's degree should be in literature before 1660.

Candidates for the doctor's degree are accepted only after a consultation with the graduate committee concerning the candidate's qualifications. Each candidate is required to take at least one course from the following sequence: Engl 421, History of the English Language; Engl 423, Old English; and Engl 424, Beowulf.

The foreign language requirement for the doctor of philosophy (usually in Latin, French or German) may be satisfied in one of two ways: 1. the demonstration, through examination, of a reading knowledge of two foreign languages; or 2. the successful completion, concurrent with the graduate program, of a foreign language course, to be approved by the departmental director of graduate studies, at the 200, 300, or 400 level (or at a lower level in classical languages).

For the doctoral examination each candidate selects the following to be examined upon:

1. One of the following traditional periods: Old English and Medieval; Renaissance and Jacobean, 1500-1660; Restoration and Eighteenth century, 1660-1798; Romantic and Victorian, 1798-1900; American Literature, Colonial-1899; Modern British and American Literature, 1900-present.
2. A major figure, to be selected in consultation with the director of graduate studies and subject to the approval of the departmental graduate committee.
3. A genre, theme, matter, or customary grouping, to be selected in consultation with the director of graduate studies and subject to the approval of the departmental graduate committee.

In each of the three areas of the examination, the candidate is expected to demonstrate the knowledge and expertise that would be necessary to teach a course in the subject. The three areas may not overlap except for, in rare instances, the third.

Freshman Courses

With the two exceptions noted below, all undergraduate students take six hours of freshman English courses: English 1 and one of the five options for the second semester, Engl 2, 4, 6, 8, 10. The exceptions are:

1. Advanced placement and six hours of Lehigh credit for freshman English are given to students who earn a score of 5 on the College Board Advanced Placement Test in English. These students need not take the regular freshman English courses (English 1, 2, 4, 6, 8, 10), but they are encouraged to elect Engl 11 and 12, seminars designed to give advanced freshman practice in reading and writing at the college level. Students who receive a grade of 4 on the Advanced Placement Test in English or who have a score of 700 or higher on the SAT Verbal Aptitude Test will receive three hours of credit in freshman English; these students will complete the six-hour requirement by taking Engl 2, 4, 6, 8, 10, 11, 12 or 171. Students in this category should seek advice from the department about which courses to roster. Students who have an SAT Verbal Aptitude Test score between 650 and 699 and who have received a grade of 3 on the College Board Advanced Placement Test in English may apply to the department for an anticipatory or special examination which, if completed successfully, will result in three hours of credit and exemption from Engl 1.
2. Students with English as a Second Language. Categories include students on non-immigrant visas, students on immigrant visas, registered aliens, and citizens either by birth or by naturalization.

Students in all these categories for whom English is not the first language may petition for special instruction through the program in English as a Second Language.

At matriculation, all foreign students take an English-language competence test to determine the kind of instruction best suited to their needs. Matriculating freshmen judged to be qualified will roster Engl 1, followed by Engl 2, 4, 6, 8, or 10. Others will be enrolled in Engl 3, followed by Engl 5 (or 2, 4, 6, 8, or 10).

Students enrolled in the English as a Second Language program are expected to reach a level of competence comparable to those in the usual freshman program. The form of instruction, however, will differ in the ESL program by taking into account the special problems of non-native speakers.

Matriculating students in all the above categories who are entering at a level above the freshman year, but who need composition credit, should consult the department for advice.

Courses in English

1. Composition and Literature (3)
The art of expository writing. Appropriate collateral reading.

2. Composition and Literature: Fiction, Drama, Poetry (3)
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of fiction, drama, and poetry. Prerequisite: Engl 1.

3. English as a Second Language (3)
Idiomatic English both oral and written, with a strong emphasis on producing well-organized, coherent essays. Enrollment limited to non-native speakers; placement is determined after testing by the Department of English.

4. Composition and Literature: The Novel (3) spring
Continuation of Engl 1. Further practice in expository writing in conjunction with study of selected novels. Prerequisite: Engl 1.

5. English as Second Language II (3)
Continuation of English 3.

6. Composition and Literature: Drama (3) spring
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of literary and theatrical aspects of several classic and contemporary plays. Prerequisite: Engl 1.

8. Composition and Film Study (3) spring
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of film. Prerequisite: Engl 1.

10. Composition and Literature: Fiction (3) spring
Continuation of Engl 1. Further practice in expository writing in conjunction with the study of short stories, novellas, and novels. Prerequisite: Engl 1.

11. Literature Seminar for Freshmen (3) fall
Discussion of and writing about selected masterworks of literature. Open as an elective to any freshman exempt from the regular freshman English requirement.

12. Literature Seminar for Freshmen (3) spring
Discussion of and writing about selected masterworks of literature. Open as an elective to any freshman exempt from the regular freshman English requirement. After passing Engl 1, students judged to be qualified may complete the English composition requirement by taking this course instead of Engl 2, 4, 6, 8, or 10.

Basic Undergraduate Courses

The following courses are open to any student who has completed, or who is exempt from, the required six hours of freshman English. Students may roster one of the following as a second English course to be taken concurrently with Engl 2, 4, 6, 8, or 10, if they have earned a grade of B or above in Engl 1.

23. American Literature (3) fall
Significant American writing from the settlement through the middle of the 19th century. Prerequisite: six hours of freshman English.

24. American Literature (3) spring
American literature from the middle of the 19th century to the present. Prerequisite: six hours of freshman English

25. British Literature (3) fall
British literature from Beowulf through the Pre-Romantics. Prerequisite: six hours of freshman English.

26. British Literature (3) spring
British literature from Wordsworth to Auden. Prerequisite: six hours of freshman English.

53. The Short Story (3)
English, American and continental short story. Class discussions, collateral reading, and reports. Prerequisite: six hours of freshman English.

59. World Literature (3)
Great works from the literature of epic poetry, drama, romance, and essay that illustrate the humanistic traditions of Western civilization. Prerequisite: six hours of freshman English.

63. Narrative Film (3)
History and aesthetics of narrative film. May be repeated for credit as title varies. Prerequisite: six hours of freshman English. Doty

72. Words (1-3)
Improving vocabulary, spelling, and diction through study of word formation, etymology, prefixes, suffixes. Students rostering one credit hour will complete programmed texts emphasizing morphology and etymology. Additional credit hours added for study emphasizing denotation and connotation in literary contexts and for independent study requiring a paper. Hook

73. Creative Writing Workshop (1-3)
Practice in and classroom criticism of creative writing done by students taking the course. Title may vary: Short Story; Drama; Poetry; etc. May be repeated for credit. Prerequisite: six hours of freshman English.

74. Editing the Manuscript (1)
How to improve your papers by editing: spelling, punctuation, proper usage, and correct grammar.

85. Performing Literature (1-3)
Study of and practice in literature to be performed before an audience. Title will vary: Readers Theater. May be repeated for credit as title varies.

89. Science Fiction (3)
From 'hard SF' to high fantasy. The fusing of aesthetic, philosophical, scientific and technological orientations in the literature of our post-atomic culture. Prerequisite: six hours of freshman English. Arbur

91. Special Topics in English (1-3)
A topic, genre, or approach in literature or writing not covered in other courses.
Prerequisite: six hours of freshman English.

Upperclass Undergraduate Courses

The following courses are more advanced than the courses that appear in the preceding list, but they are by no means designed exclusively for specialized students. Each course is a self-contained unit and has no prerequisites beyond the two semesters of freshman English.

The purpose of most of the courses listed below is to acquaint students from all segments of the university with the best that has been written through the ages by the most effective literary artists. *These courses may be used to fulfill preliminary or upperclass distribution requirements for students in the College of Arts and Science.*

119. Literature and Technology (3)
Reflections of and reactions to technological progress by major writers of the 18th, 19th and 20th centuries, such as Swift, Dickens, Twain, and Vonnegut. Prerequisite: six hours of freshman English. Gallagher

129. Shakespeare and Elizabethan Drama (3) fall
Study of the earlier plays of Shakespeare, mostly comedies and histories. Selected plays from contemporary dramatists such as Marlowe, Greene, and Jonson. Meets with Engl 329, but has a reduced reading and written assignment load. Prerequisite: six hours of freshman English. Hook, Traister

130. Shakespeare and Elizabethan Drama (3) spring
Study of the later plays of Shakespeare, the tragedies and romances. Selected plays from contemporary dramatists such as Webster, Tourneur, Middleton. Meets with Engl 330, but has a reduced reading and written assignment load. Prerequisite: six hours of freshman English. Hook, Traister

151. The Drama (3)
Selected plays; theories of drama; drama and the stage. Prerequisite: six hours of freshman English.

155. The Novel (3)
Selected novels as works of literature. Prerequisite: six hours of freshman English.

157. Poetry (3)
Traditional and modern poetry read for pleasure and understanding. Prerequisite: six hours of freshman English.

171. Practical Writing I (1-3)
Practice in and criticism of expository writing beyond the freshman level. Prerequisite: six hours of freshman English.

172. Practical Writing II (1-3)
Continuation of Engl 171. Prerequisite: Engl 171.

175. Individual Authors (1-3)
Intensive study of the works of one or more literary artists. Title will vary: Hemingway; Tolkien. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

177. Individual Works (1-3)
Intensive study of one or more literary works. Title will vary: Moby Dick; Stories of John Cheever. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

179. Character Types in Literature (1-3)
Study of a character type in several works of literature by several authors. Title will vary: The Scientist in Drama and Fiction; The Magician in Literature. May be repeated for credit as the title varies. Prerequisite: six hours of freshman English.

181. Undergraduate Thesis (3)
Open to advanced undergraduates who wish to submit theses in English. Prerequisite: consent of the department chairperson.

183. Readings in English and American Literature (3)
Open to advanced students who wish to pursue special or independent courses of reading in literary study. Prerequisite: consent of the department chairperson.

187. Themes in Literature (1-3)
Study of a recurring theme as it appears in several works of literature. Title will vary: Utopian Literature; Censorship and Literature. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

189. Popular Literature (1-3)
A form of literature that is or has been of interest primarily to a 'popular' audience. Title will vary: Folklore; Detective Fiction. May be repeated for credit as title varies. Prerequisite: six hours of freshman English.

191. Special Topics (1-3)
A topic, genre, or approach in literature or writing not covered in other courses. Prerequisite: six hours of freshman English

201. Special Topics in Writing (1-3)
Approaches not covered in other writing courses. Individual projects. May be repeated for credit. Prerequisite: Engl 171, or consent of department chair.

248. Introduction to the English Language (3)
Basic linguistic concepts together with a historical survey of the English language. Vickrey

263. Film History and Criticism (3)
Study of certain films, dealing with a particular genre, director, theory, period or theme. May be repeated for credit as title varies. Doty

281. Internship (3)
Projects on or off campus in business, professional, or government organizations. Projects approved by department committee on internships and supervised by department internship adviser. Project includes extensive writing that can be submitted for evaluation. Enrollment limited to juniors or seniors with a major or minor in English. Prerequisite: consent of department chair. Harson

291. Special Topics (1-3)
A topic, genre, or approach in literature or writing not covered in other courses.

301. Topics in Literature (1-3)
A theme, topic or genre in literature. Title will vary: Autobiography as Literature; British Drama. May be repeated for credit as title varies.

311. Literature of Women (3)
Women's works about women: is literary creativity gender-identified? Are there specifically "feminine" subjects of themes? Besides re-reading some familiar fiction, drama, and poems, introduction to contemporary and often experimental works be less famous writers. Arbur

312. Jewish Literature (3)
Development of Jewish literature (including Yiddish literature in translation) from Russian and Eastern European beginnings to immigration and assimilation in America. Fifer

316. The Indian in American Literature (3)
The American Indian as portrayed in folklore, poetry, and fiction in America. Works written by both Indian and non-Indian writers. Beidler

319. The Black in American Literature (3)
Black characters and the literary treatment of the black experience in American fiction and drama from 1850 to the present. Comparative examination of both black and non-black authors, such as W.W. Brown, Stowe, Melville, Twain, Chestnutt, Hughes, Toomer, Faulkner, Wright, Baldwin, Ellison, Styron, and Baraka. Frakes

327. Chaucer (3)
The chief works of Geoffrey Chaucer, with attention to his language and the backgrounds of his works. Beidler

329. Shakespeare and Elizabethan Drama (3) fall
Study of the earlier plays of Shakespeare, mostly comedies and histories. Selected plays from contemporary dramatists such as Marlowe, Greene, and Jonson. Hook, Traister

330. Shakespeare and Elizabethan Drama (3) spring
Study of the later plays of Shakespeare, the tragedies and romances. Selected plays from contemporary dramatists such as Webster, Tourneur, Middleton. Hook, Traister

331. Milton (3)
Life and works of John Milton in connection with the history of his times and the chief sources of his inspiration. Greene

348. Theory and Practice of Writing (3)
Approaches to writing, ancient to modern; practice in composition. Theory and practice to help students develop strategies for writing effectively. Prerequisite: Engl 171, or consent of department chair. Lotto

356. The Novel (3)
The novel as a literary form; selected novels from England, America, and the continent. Emphasis on a theme, period, or type.

360. Middle English Literature (3)
Major literary works of the Middle English period by authors other than Chaucer. Emphasis on Piers Plowman, the Gawain/Pearl Poet and the metrical romances. Hartung

362. The Renaissance (3)
English nondramatic literature in the 16th century and the stimulus of the Italian Renaissance and northern humanism. Readings in and class discussions of the works of the chief writers: Petrarch, Erasmus, More, Wyatt, Surrey, Lyly, Sidney, and Spenser. Greene

364. The Seventeenth Century (3)
English literature of the 17th century, from Donne to Dryden. Traister

367. The Eighteenth Century (3)
Great British writers of the 18th century, beginning with the Restoration: Dryden, Pope, Swift, Defoe, Fielding, and Johnson and his circle. James, Fergus

369. British Romantic Literature (3)
Poetry and prose of Wordsworth, Coleridge, Byron, Shelly, and Keats within the contemporary, political, religious and social context. Harson

371. British Victorian Literature (3)
Poetry and prose of Tennyson, Browning, Arnold, Swinburne, Carlyle, Mill, Newman, and Ruskin within the contemporary political, religious, and social context. Bross

375. Major Authors (1-3)
The works of one or more major literary figures studied in depth. May be repeated for credit as title varies.

376. Early American Literature (3)
American literature to the Romantic period. Gallagher

377. American Romanticism (3)
The chief American Romantics: Emerson, Thoreau, Whitman, Hawthorne, Melville, and Dickinson. The European and American philosophical, historical, and social background as well as the aesthetic study of romantic masterpieces. Arbur, DeBellis

378. American Realism (3)
Theory and practice of realistic fiction from the Civil War to the early 20th century: Twain, Howells, James, Norris, Crane, Chopin, Dreiser, and others. Frakes

379. Twentieth-Century American Literature (3)
American literature before World War II. Lectures and class discussion of major fiction and poetry. DeBellis, Mundhenk

380. Contemporary American Literature (3)
American literature since World War II. Lectures and class discussions of new writers and of recent works of established writers. DeBellis, Frakes

382. Themes in American Literature (3)
Intensive study of one topic in American literature. Readings from the colonial period to the present. May be repeated for credit as title varies. Frakes

383. Modernism and Post-Modernism in Fiction (3)
The 'anti-realistic' novel; time/space, point of view, narrative voice, structure as meaning. Kafka, Woolf, Beckett, Nabokov, Robbe-Grillet, Faulkner, Borges, Hawkes, Stein. Frakes

385. Twentieth-Century World Literature (3)
World English literature and continental literature before World War II. Lectures and class discussion of major fiction and poetry.

386. Contemporary World Literature (3)
World English literature and continental literature since World War II. Lectures and class discussions of new writers and of recent works by established writers. Frakes

391. Special Topics (1-3)
A topic, genre, or approach in literature or writing not covered in other courses.

Graduate Courses in English

The following courses are seminars, ordinarily limited to no more than twelve graduate students, but undergraduate English majors who are planning to go on to graduate school in English and who have shown proficiency in the study of literature may petition to take one of these seminars in their senior year.

421. History of the English Language (3)
The phonology, grammar, and lexicon of English from the beginnings to the present. Vickrey

423. Old English (3)
Old English language and literature. Vickrey

424. Beowulf (3)
The Beowulf poem and some of the pertinent scholarship. Vickrey

427. Chaucer (3)
Chaucer's language. The Canterbury Tales. Readings, reports, and discussions. Hartung

428. Chaucer (3)
Chaucer's Minor Poems, Troilus and other pre-Canterbury period works. The 15th-century 'Chaucerians.' Readings, reports, and discussions. Hartung

429. Middle English Metrical Romances (3)
Non-Arthurian verse romances. Introduction to paleography. Folk and court backgrounds. Narrative theory. Hartung

431. Arthurian Literature of the Middle Ages (3)
Arthurian literature from its Celtic Beginnings to Malory's *Morte D'Arthur*. Hartung

433. Middle English Literature (3)
A topic, a genre, or a grouping of works or authors in the Middle English period. Sample offerings: The Medieval Comic Tale; Medieval Drama. May be repeated for credit as title varies. Beidler

439. Sixteenth-Century British Literature (3)
A topic, a genre, or a grouping of works or authors in the 16th century. Sample offerings: 16th Century Drama, Spenser. May be repeated for credit as title varies. Hook, Traister

441. Seventeenth-Century British Literature (3)
A topic, a genre, or a grouping of works or authors in the 17th century. Sample offerings: Jacobean and Caroline Drama; Metaphysical Poetry. May be repeated for credit as title varies. Hook, Traister

443. Eighteenth-Century British Literature (3)
A topic, a genre, or a grouping of works or authors in the 18th century. Sample offerings: The Rise of the Novel; Boswell, Johnson, and their circle. May be repeated for credit as title varies. James, Fergus

445. Nineteenth-Century British Literature (3)
A topic, a genre, or a grouping of works or authors in the Romantic or Victorian periods. Sample offerings: Wordsworth and Byron; The Victorian Novel. May be repeated for credit as title varies. Bross, Harson, Mundhenk

449. Twentieth-Century British Literature (3)
A topic, a genre, or a grouping of works or authors in 20th century literature of the British Isles. Sample offerings: Conrad; Joyce. May be repeated for credit as title varies. Frakes, Greene, Bross

471. Early American Literature (3)
A topic, a genre, or a grouping of works or authors of colonial America or the early republic. Sample offerings: The Roots of the American Dream; Science and Religion in the Colonial Period. May be repeated for credit as title varies. Gallagher

473. American Romanticism (3)
A topic, a genre, or a grouping of works or authors in the American Romantic period. Sample offerings: The Nature of Evil in Hawthorne; Melville and Poe. May be repeated for credit as title varies. Arbur, DeBellis

475. American Realism (3)
A topic, a genre, or a grouping of works or authors in American literature from the Civil War to World War I. Sample offerings: James; American Literary Naturalism. May be repeated for credit as title varies. Frakes

477. Modern American Literature (3)
A topic, a genre, or a grouping of works or authors in the literature written after World War I. Sample offerings: Hemingway and Faulkner; Southern Writers. May be repeated for credit as title varies. DeBellis, Frakes

481. Literary Criticism (3)
Theory and practice of criticism. The nature and function of literature itself, the assumptions and methodologies of major 20th century critical 'schools,' and similar topics, regarded as objects of knowledge and as models for students' own critical reading, writing, and teaching. May be repeated for credit as title varies. Arbur

485. Teaching of College English (3)
History, theory, and practice of teaching the freshman composition course. Required of all new teaching assistants in the department of English. May be rostered by others only with consent of the department chairperson.

489. Workshop for English Teachers (1-3)
Study of a body of information with particular emphasis, through reports and discussion, on how the information can best be taught to secondary and college students. Sample offerings: Shakespeare for Teachers; Teaching the Novel; Teaching Poetry. May be repeated for credit as title varies.

491. Special Topics (1-3)
A topic, genre, or approach in literature or writing not covered in other courses. May be repeated for credit as title varies. Prerequisite: consent of the graduate program coordinator.

493. Graduate Seminar (3)
Intensive study of the works of one or more authors, or of a type of literature, or of the teaching of an author or a type of literature. May be repeated for credit as title varies.

495. Independent Study (3)
Independent study in approved areas. To be rostered by candidates for the master of arts degree in English who desire to take an examination on selected figures rather than submit a thesis. Prerequisite: consent of the graduate program coordinator.

Environmental Sciences and Resource Management

Edward B. Evenson, Ph.D. (Michigan), *director,* professor of geological sciences.
Concentration advisers. David L. Cundall, Ph.D. (Arkansas), *biology;* Robert S. Sprague, Ph.D. (Illinois), *chemistry;* Sharon M. Friedman, M.A. (Penn State), *environmental science writing;* Edward B. Evenson, Ph.D. (Michigan), *geology.*

Society's increasing demands for energy, water, mineral commodities, food, recreational and living space have altered and will continue to alter the global ecosystem. The need for personnel trained to evaluate proposed alterations and to repair existing deleterious or critical situations can best be met by an interdisciplinary approach. Additionally, there is pressing need to communicate about environmental problems at all levels of society, from the scientist to the layman. Writing about the environment can best be done by persons trained in both science and communication skills.

Environmental sciences and resource management is an interdepartmental major fostering basic preparation for advanced study or an immediate career in environmental management, conservation and environmental science writing. The backgrounds of fundamental mathematics and science required to understand the interactions of humans and their environment are established early in the major where the student is exposed to the core courses of mathematics, chemistry, physics, biology and geology.

Following this basic preparation, students select a concentration area within which more advanced training is undertaken. Concentrations in biology, chemistry, geology and environmental science writing have been established and concentrations in other fields can be designed to meet the needs and career desires of individual students.

Student research, work experience, and internships involving laboratory, field, library or mass media research is an integral part of the program and is strongly encouraged.

Graduates of this major can expect to take part in planning, education, research and coordination of environmental programs for all levels of government and industry. Those concentrating in environmental science writing also can pursue careers in science journalism or in professions such as environmental law or environmental management, where communication skills are highly desired. Graduate study is advisable for students wishing to pursue a career in most aspects of environmental science and the program provides thorough preparation for advanced training in environmental science or concentration areas.

B.S. in Environmental Sciences and Resource Management

Major Requirements

The program requires 121 credit hours. Credit is allocated as follows: 37 credits for college and university requirements, 66 credits in preliminary courses, and 18 credit hours in the area of concentration.

college and university requirements (36 credit hours)

Art 1	Introduction to Art History I (3)
Engl 1	Composition and Literature (3)
Engl 2, 4, 6, 8, 10 or 16	Composition and Literature: Fiction, Drama, Poetry (3)
	general electives (30)

Note: General elective courses are non-professional courses designed to give the student a broad understanding in traditional and contemporary fields of thought outside of natural science and mathematics. The elective program (30 hours minimum) shall include at least twelve hours of humanities and twelve hours of social sciences.

required preliminary courses (66 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)
Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Laboratory I (1)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Laboratory (1)
Chem 31	Chemical Equilibria in Aqueous Systems (3)
Chem 51	Organic Chemistry (3)
Chem 53	Organic Chemistry Laboratory (1)
Geol 11	Environmental Geology (3)
Geol-21*	Principles in Geology (3); **or**
Geol 101	Geology for Engineers (3)
Geol-22*	Introductory Geology Laboratory (1)
Geol-31*	Historical Geology and Stratigraphy (3)
Geol 133	Introductory Mineralogy and Petrology (3)
Biol 21	Principles of Biology (3)
Biol 22	Introduction to Biology Laboratory (1)
Biol 133	Invertebrate Zoology (3)
Biol 151	Vertebrate Field Biolgy (3)
Biol 211	Ecology (3) or
Biol 309	Aquatic Biology (3)
Eco 311	Environmental Economics (3) **or**
Eco 314	Energy Economics (3)
Jour 123	Basic Science and Technical Writing (3)

*Geol 41 Physical and Historical Geology in the Rocky Mountains (6) may be substituted for Geol 21, 22, and 31.

Concentrations

Eighteen credit hours required. Students should select and fulfill one of the following areas of concentration. The courses in each concentration area have been recommended and approved by the respective departments.

Geology Concentration

Geol 123	Structural Geology (3)
Geol 312	Geomorphology (3)
Geol 313	Sedimentology (3)
Geol 333	Crystallography (3) **or**
Geol 356	Ground Water (3)
Geol 341	Field Geology (6)

Biology Concentration

Chem 52	Organic Chemistry (3)
Biol 28	Mendelian and Population Genetics (3)
Biol 131	Non-Vascular Plants (3) **or**
Biol 132	Evolution of Vascular Plants (3)
Biol 223	Animal Physiology (3)
Biol 235	Microbiology (3)
Biol	Approved Field Course (3)

Chemistry Concentration

Chem 52	Organic Chemistry (3)
Chem 54	Organic Chemistry Laboratory (2)
Chem 187	Physical Chemistry I (3)
Chem 189	Physical Chemistry II (3)
Chem 234	Analytical Chemistry Laboratory (1)
Chem 332	Analytical Chemistry (3)
CE 374	Environmental Chemistry I (3)

Environmental Science Writing Concentration

Jour 117	Magazine Article Writing (3) **or**
Jour 114	Reporting of Public Affairs (4) **or**

Jour 312	Advanced Science Writing (3)
Jour 113	Editing (3)
Jour 124	Politics of Science (3)
Jour 125	Environment, the Public and the Mass Media (3)
Jour 128	Writing for Public Relations (3)
Jour 313	Special Topics in Science Writing (3)

Recommended Sequence of Courses

freshman year, first semester (15 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Engl 1	Composition and Literature (3)
	general elective (3)

freshman year, second semester (14 credit hours)

Math 22	Analytic Geometry and Calculus II (4)
Geol 21, 22*	Principles of Geology and Introductory Geology Laboratory (4)
Engl 2, 4, 6, 8 or 10	Composition and Literature: Fiction, Drama, Poetry (3)
	general elective (3)

summer

Geol 41*	Physical and Historical Geology in the Rocky Mountains (6)

(this course may be substituted for Geol 21, 22, and 31.)

sophomore year, first semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Phys 11, 12	Introductory Physics I and Laboratory I (5)
Biol 21, 22	Principles of Biology and Laboratory (4)
Geol 11	Environmental Geology (3)

sophomore year, second semester (14 credit hours)

Phys 21, 22	Introductory Physics II and Laboratory II (5)
Geol-31*	Historical Geology and Stratigraphy (3)
	concentration course (3)
	general elective (3)

junior year, first semester (16 credit hours)

Chem 51, 53	Organic Chemistry and Laboratory (4)
Geol 133	Introductory Mineralogy and Petrology (3)
Biol 151	Vertebrate Field Biolgy (3)
	concentration course (3)
	general elective (3)

junior year, second semester (15 credit hours)

Chem 23	Environmental Aspects of Analytical Chemistry (3) **or**
Chem 31	Chemical Equilibria in Aqueous Systems (3)
Biol 211	Ecology (3) **or**
Biol 309	Aquatic Biology (3)
	concentration course (3)
	general electives (6)

summer

Geol 341	Field Geology (6) Geology concentration only.
Biol	Approved field course (3) Biology concentration only.

senior year, first semester (15 credit hours)

Biol 133	Invertebrate Zoology (3)
Jour 123	Basic Science and Technical Writing (3)
	concentration course (3)
	general electives (6)

senior year, second semester (15 credit hours)

Eco 311	Environmental Economics (3) **or**
Eco 314	Energy Economics (3)
	concentration courses (6)
	general electives (6)

Finance

Professors. Carl R. Beidleman, Ph.D. (Pennsylvania), *DuBois Professor of Finance, chairperson;* Eli Schwartz, Ph.D. (Brown), *Macfarlane Professor of Economics.*
Associate professors. Stephen G. Buell, Ph.D. (Lehigh); James A. Greenleaf, Ph.D. (N.Y.U.).
Assistant professors. John B. Guerard, Ph.D. (Texas); John David Leahigh, Ph.D. (Georgetown); Stephen F. Thode, D.B.A. (Indiana).

The finance major offered in the College of Business and Economics requires fifteen credit hours beyond the core listed on page 35. Each finance major selects either the Business Finance or Financial Economics track.

Business Finance

required courses:

Fin 323	Investments (3)
Fin 328	Corporate Financial Policy (3)

plus two of the following:

Fin 324	Security Analysis (3)
Fin 330	Financial Flows and Markets (3)
Fin 331	Bank Management (3)
Fin 333	Multinational Business Finance (3)
Fin 334	Speculative Markets (3)

plus one additional 300-level finance or finance/economics course.

Financial Economics

required courses:

Fin 323	Investments (3)
Fin 328	Corporate Financial Policy (3)

plus two of the following:

Fin 332	Monetary-Fiscal Policy (3)
Fin 340	International Finance (3)
Fin 353	Public Finance: Federal (3)
Fin 354	Public Finance: State and Local (3)

plus one additional 300-level finance or finance/economics course.

For Advanced Undergraduates and Graduates

225. Business Finance (3) fall-spring
Introductory corporation finance, which stresses a managerial approach to asset management and capital structure. Financial policies regarding the acquisition of funds and their allocation among competing assets within the firm. Prerequisites: Eco 145, Eco 105, Math 41 and 44, Acct 51.

323. Investments (3) spring
The nature of risk and the form of returns to financial assets. Investor objectives, attitudes, and constraints are considered within the risk-return matrix as the basis for investment decisions. Problems of timing, market characteristics, and portfolio management. Prerequisite: Fin 225. Greenleaf

324. Security Analysis (3) fall
Factors influencing the value of financial securities: earnings forecasts and expectations, uncertainty, required returns, supply and demand for securities and funds, and investor attitudes. Implications of market factors, technical approaches, timing, and screening. Prerequisites: Acct 111 and Fin 323. Not ordinarily open to CBE graduate students. Beidleman, Buell, Guerard

328. Corporate Financial Policy (3) spring
Advanced corporate finance; capital budgeting, working capital management, leasing, mergers, and financing. Case studies and complex problems. Prerequisite: Fin 225. Not ordinarily open to CBE graduate students. Thode, Guerard

330. Financial Flows and Markets (3) fall
Functions and portfolios of financial intermediaries. Sectoral demand and supply of funds, nature and role of interest rates, term structure and forecasting, impact of inflation and regulation on financial intermediaries and markets, and current developments in the financial system. Prerequisites: Eco 229 and Fin 225. Not ordinarily open to CBE graduate students. Leahigh

331. Bank Management (3) spring
Management of bank assets and liabilities within U.S. system's legal and economic constraints. Bank Management Simulator is used to examine relationships between asset, liability, and profitability decisions. Prerequisites: Eco 229 and Fin 225 senior standing or consent of instructor. Not ordinarily open to CBE graduate students. Leahigh

332. (Eco 332) Monetary-Fiscal Policy (3)
Monetary, credit and fiscal policies of government and central banks, with particular reference to the policies of the United States Treasury and the Federal Reserve System. Prerequisite: Eco 119 or 229. Schwartz

333. Multinational Business Finance (3) spring
Issues that underlie the investment, financing, and dividend decisions of multinational firms, Current transactions in foreign currencies, direct and portfolio investment and associated risk management when dealing in foreign countries. Prerequisite: Fin 328. Not ordinarily open to CBE graduate students. Beidleman

334. Speculative Markets (3) spring
Theoretical and empirical analysis of speculation in various markets, particularly options and futures markets. Term project required. Not ordinarily open to CBE graduate students. Prerequisite: Fin 323. Guerard, Greenleaf

340. (Eco 340) International Finance (3)
Analysis of balance of payments and disturbances and adjustment in the international economy; international monetary policies. Prerequisite: Eco 229. Callahan, Gunter

353. (Eco 353) Public Finance: Federal (3)
A course dealing with government expenditures and revenues, the economics of taxation, and government administration. Aronson, Munley

354. (Eco 354) Public Finance: State and Local (3)
The major issues regarding revenues, expenditures, debt and budgeting policy are examined in the light of fiscal principles and economic effects of state and local governments. Special attention is placed on intergovernmental fiscal relations. Aronson, Munley

371. Directed Readings (3)
Readings in various fields of finance designed for the student with a special interest in some field of finance not covered in scheduled courses. Prerequisite: consent of the department chairperson. May be repeated.

372. Special Topics (1-3)
Special problems and issues in finance for which no regularly scheduled course work exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: consent of department chairperson. May be repeated.

For Graduate Students

411. Financial Management (3) fall
Introduction to financial management, with consideration of advanced topics, with respect to: risk, valuation, capital structure, dividends, capital budgeting, and working capital management. Prerequisites: Acct 403, Eco 401, and Eco 405.

430. Investments and Portfolio Management (3) fall
Investment instruments and institutions, historical performance, technical analysis, risk and diversification, portfolio theory. Prerequisite: Fin 411. Greenleaf

431. Advanced Investment and Portfolio Analysis (3) spring
Theoretical and empirical examination of recent developments in portfolio theory. Prerequisite: Fin 430. Guerard

432. Financial Management of Financial Institutions (3) fall
Asset and liability management of commercial banks, savings and loan associations, life insurance companies, and pension funds. Short and long run responses to changes in economic conditions, interest rates, and regulations. Prerequisite: Fin 411. Leahigh

433. (Eco 433) Valuation seminar (3) fall
Determinants of financial asset values. The role of uncertainty, imprecise forecasts, risk preferences, inflation, and market conditions. Prerequisite: Fin 411. Beidleman, Buell

434. Cases in Financial Management (3) fall
Integration of multiple topics in corporation finance through analysis of complex cases, including: capital budgeting, working capital management, leasing, mergers, and financing. Prerequisite: Fin 411. Thode

436. International Financial Management (3) spring
Financial management of multinational firms. Consideration of problems arising from diversity of currencies, investment opportunities, risk, and international capital markets. Case studies. Prerequisite: Fin 411. Beidleman

442. (Eco 442) Foreign Trade Management (3) spring, odd-numbered years
Foreign operations, including export channels in foreign markets, export and import financing, foreign investments, and policies of government and international agencies.

444. (Eco 444) Banking and Monetary Policy (3)
Analysis of the U.S. monetary and banking systems. Financial markets. Central bank controls, monetary theory and policy. Prerequisite: a course in money and banking. Innes, Schwartz

447. (Eco 447) Capital and Interest Theory (3) alternate years
Theories of interest and capital. Annuities; applications of present value theory; investment valuation under uncertainty and risk; term structure of interest rates; the theory of savings, cost of capital and capital formation. Prerequisite: a course in finance. Schwartz

449. (Eco 449) Public Finance (3) spring, even-numbered years
The economics of public spending and taxation; principles of government debt management; theories of budgeting and cost-benefit analysis and public choice. Aronson, Munley

451. Quantitative Financial Models (3) alternate years
Relationship of quantitative models to financial theory and applications. Capital budgeting, portfolio selection, security evaluation, cash management, inventory policy and credit analysis. Prerequisite: Fin 411. Guerard

456. Options and Financial Futures (3) spring
Examination of the options pricing model and its implications for options management and equity pricing. Theory and applications for hedging and speculation. Emphasis is placed on trading of options on debt, equity, stock indices and futures. Financial futures and index futures are also examined for their contributions to individual portfolio management. Prerequisite: Finance 430. Guerard

457. (Eco 457) Monetary Theory (3)
The role of money in the economy from theoretical and empirical perspectives. The influence of money and prices, interest rates, output and employment. Prerequisite: Eco/Fin 444 or equivalent. Innes, Callahan

459. (Eco 459) International Financial Economics (3)
Analysis of the structure and functioning of the international monetary system, international capital markets, Eurocurrency markets, fixed and floating exchange rates, and the role of international monetary institutions in foreign exchange risk management. Callahan, Gunter

471. Directed Readings (1-3)
Readings in finance not covered in regularly scheduled coursework. Prerequisite: consent of the department chairperson. May be repeated.

472. Special Topics (1-3)
Problems and issues in finance for which no regularly scheduled graduate couse work exists. When offered as group study, coverage varies according to interest in finance. Prerequisite: consent of the department chairperson. May be repeated.

Fine Arts

See listings under Art and Architecture.

Five-Year Programs

There are a number of ways in which students can obtain two degrees in five years of study. See listings under Arts-Engineering; Arts-Master of Business Administration; Civil Engineering and Geological Sciences; Electrical Engineering and Engineering Physics; and Engineering-Master of Business Administration.

Foreign Careers

Alvin Cohen, Ph.D. (Florida), professor of economics and *director*, Foreign Careers program.

This major in the College of Arts and Science is designed to meet the needs of the student who has decided upon an international business, law, or political focus for his education. It uses elements of the traditional liberal arts and business school curricula. Among those traditional liberal arts elements are courses in economics, government, history, international relations, and language. With respect to business school offerings, there are courses in accounting, finance, and statistics. The major also represents an excellent foundation for graduate study in business, law, and the social sciences.

Each student completes the courses in the common core, takes twelve credit hours from offerings in economics, government, history, international relations, and social relations as related to an area of geographical concentration, and eighteen credit hours in a functional option. Although not a requirement, students should study the language related to their area of specialization.

Major Requirements

Common Core

(13 credit hours)

Eco 1	Economics (4)
Govt 3	Comparative Politics (3)
Math 21	Analytic Geometry and Calculus I (4) **or**
Math 41	BMSS Calculus I (3)
Eco 145	Statistical Methods (3) **or** a comparable course in statistics

Geographical Concentrations

(12 credit hours in one of the areas listed)

Latin America, Europe, Russia, East Asia, the Middle East (select one)

The student selects four courses from the offerings of the relevant departments, with the consent of the director.

Functional Options

(18 credit hours in one of the options listed)

International Business Concentration

Acct 51	Introduction to Financial Accounting (3) **or**
Acct 108	Fundamentals of Accounting (3)
Eco 105	Intermediate Microeconomic Analysis (3)
Eco 119	Intermediate Macroeconomic Analysis (3)
Eco 229	Money and Banking (3)
Eco 303	Economic Development (3)
Eco 339	International Trade (3) **or**
Eco/Fin 340	International Finance (3)

Public Administration Concentration

Acct 51	Introduction to Financial Accounting (3) **or**
Acct 108	Fundamentals of Accounting (3)
IR 353	International Institutions (3) **or**
IR 361	International Law (3)
Eco 353	Public Finance: Federal (3)
Govt 360	Public Administration (3)
Govt 306	Public Policy Process (3) **or**
Govt 355	Public Personnel (3)
Govt 322	Politics of Developing Nations (3) **or**
Eco 303	Economic Development (3)

Open Option Concentration

With the consent of the director, the student may combine eighteen credit hours more flexibly than is the case with either the international business or the public administration option.

Foreign Culture And Civilization

See listings under Modern Foreign Languages.

Foreign Literature

See listings under Classics and under Modern Foreign Languages.

French

See listings under Modern Foreign Languages.

Fundamental Sciences

Curtis W. Clump, Ph.D. (Carnegie-Mellon), *associate dean* of the College of Engineering and Applied Science, *director* of the fundamental sciences program.

The curriculum in fundamental sciences is designed to enable students to achieve a breadth of academic background in the fields of modern science and at the same time, through an option, to master the discipline of one of them, approximately to the level of a minimum bachelor's program. The options and electives provide sufficient flexibility to enable a student to prepare for employment in industry or government or approach adequacy for graduate study in a field.

Fundamental science students are required to concentrate in a major. Students can organize acceptable programs including the substantive course elements related to any one among several areas such as chemistry, physics and mathematics, biology, earth and space science, science of living systems, materials, computer science, and architecture, or meaningful combinations of any two.

The freshman year is identical with that of all students in the College of Engineering and Applied Science. The General Studies requirements of the college must also be satisfied. The discipline of a field will be provided by the inclusion of at least fifteen semester hours or from a combination that constitutes the core of one of the combination fields. Examples of these combination major include: biochemistry, geophysics, bioengineering, applied mathematics, biophysics, and computer science. Students pursuing double concentrations may, with the approval of their adviser, substitute for one of the science courses of the sophomore year a basic course in the area of concentration.

The details of the student's program are worked out by the student with the advice of the curriculum adviser, and with the approval of the department chairperson concerned with the fields of concentration.

Recommended Sequence of Courses

freshman engineering year (see page 36)

sophomore year, first semester (15-16 credits)

Biol 21, 22	Principles of Biology and Laboratory (4) **or**
Geol 21	Principles of Geology (3)
Chem 51, 53	Organic Chemistry and Laboratory (4)
Math 23	Analytic Geometry and Calculus III (4)
Eco 1	Economics (4)

sophomore year, second semester (17 credits)

	major subject (3)
	approved elective (3)
Math 205	Linear Methods (3)
Phys 21, 22	Introductory Physics II and Laboratory (5)
	general studies elective (3)

junior year, first semester (15-16 credit hours)

Geol 21	Principles of Geology (3) **or**
Biol 21, 22	Principles of Biology and Laboratory (4)
Psyc 1	Introduction to Psychology (3)
Math 231	Probability and Statistics (3)
	major (3)
	general studies elective (3)

junior year, second semester (15 credit hours)

	approved electives (6)
	major (6)
	elective (3)

senior year, first semester (18 credit hours)

	approved electives (6)
	major (6)
	general studies elective (3)
	elective (3)*

senior year, second semester (18 credits)

Phil 128	Philosophy of Science (3)
	approved elective (3)
	major (6)
	general studies elective (3)
	elective (3)*

Geological Sciences

Professors. Bobb Carson, Ph.D. (Washington), *chairperson;* Edward B. Evenson, Ph.D. (Michigan); Paul B. Myers, Jr., Ph.D. (Lehigh); Charles B. Sclar, Ph.D. (Yale); Dale R. Simpson, Ph.D. (Cal. Tech.).
Associate professor. Kenneth P. Kodama, Ph.D. (Stanford).
Instructors. David J. Anastasio, M.A. (Johns Hopkins); Carl O. Moses, M.S. (Virginia).

Geology, geophysics, and geochemistry deal with natural phenomena on or within the earth. Each makes use of other more fundamental sciences in its practice; hence, the student preparing for a career in one of the geological sciences combines study in geology with a broad understanding of physical, chemical, and biological principles.

Lehigh offers two undergraduate programs in geological sciences, one leading to the degree of bachelor of science in geological sciences, the other to the degree of bachelor of arts. The bachelor of science curriculum is designed to permit a concentration in depth in the major whereas the bachelor of arts curriculum provides the opportunity for a broad liberal-arts education centered around geoscience. The bachelor of arts program requires fewer credits for graduation (121 vs. 127 credit hours), fewer courses in collateral sciences and mathematics (28-32 vs. 34 credit hours), and fewer required geology courses (31 vs. 42 credit hours). Candidates for the bachelor of science degree also are required to take fifteen credit hours in approved professional electives. The professional electives permit the student to arrange for an informal option in geochemistry, geophysics, engineering geology, etc. If the free electives in the bachelor of arts program are selected carefully, the B.A. program would provide the possibility of (1) a minor in an area of the humanities and social sciences; and (2) entry into graduate-level studies in fields such as geology, environmental science, marine science, environmental law, etc. Students are strongly urged to discuss the selection of free electives, career goals, and career objectives with their major advisor.

Students electing the bachelor of arts program are required to meet the distribution requirement of the College of Arts and Science; candidates for the bachelor of science degree take thirty credit hours of nonprofessional electives in place of the distribution requirements. It is strongly recommended that all students who plan to attend graduate school and who have not previously studied either French, German, or Russian include courses in one of these languages in their undergraduate program.

Both the bachelor of science program and the bachelor of arts program provide preparation for graduate school. Qualified students may be given permission at the end of the junior year to enter a program wherein they are able to begin work toward a graduate degree during the senior year. (See Combined B.A. or B.S. and M.S. program below.)

Geological training may be utilized in industry (especially in the petroleum, mining, construction engineering, ceramics, and metallurgical industries), government service, natural resource management, and in secondary school, college, and university teaching.

A major in geophysics is offered in conjunction with faculty from cooperating departments. This program is described under "Geophysics."

Major Requirements for B.S.

A total of 127 credit hours is required.

college and university, requirements (36 credit hours)

Engl 1	Composition and Literature (3)
Engl 2, 10, 14 or 16	Composition and Literature: Fiction, Drama, Poetry (3)
	electives (30 credit hours)

Elective courses are nonprofessional courses designed to give the student a broad understanding in traditional and contemporary fields of thought outside of natural science and mathematics. The courses are chosen by the student. The elective program includes a minimum of 12 credit hours in the humanities and a minimum of 12 credit hours in the social sciences as defined by the faculty for the bachelor of arts.

major program (91 credit hours)

mathematics (12 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)

collateral sciences (22 credit hours)

Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Chem 31	Chemical Equilibria in Aqueous Systems (3)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Phys 21, 22	Introductory Physics II and Laboratory (5)
Biol 21, 22	Principles of Biology and Laboratory (4)

geology (42 credit hours)

Geol 21, 22	Principles of Geology and Introductory Geology Laboratory (4) **and**
Geol 31	Historical Geology and Stratigraphy (3) **or**
Geol 41	Physical and Historical Geology in the Rocky Mountains (6)
Geol 111	Computer Applications (1)
Geol 123	Structural Geology (3)
Geol 133	Introductory Mineralogy and Petrology (3)
Mat 210 or Chem 187	Metallurgical Thermodynamics (3) **or** Physical Chemistry I (3)
Geol 301	Introduction to Geophysics (3)
Geol 311	Paleontology (3)
Geol 312	Geomorphology (3)
Geol 313	Sedimentology (3)
Geol 333	Crystallography (3)
Geol 334	Petrology and Petrography (4)
Geol 341	Field Geology (6)

Note: Geol 41 may be substituted for Geol 21, 22, and 31. Before taking Geol 341, it is recommended that a student complete Geol 21, 22, 31, 123, 133, 312, and 313.

approved professional electives (15 credit hours)
Courses approved to fulfill this requirement should form a coherent package supporting the professional objectives of the student. Examples of coherent groups of recommended courses that may serve to fulfill this requirement are as follows:

Emphasis on Mineralogy-Petrology-Economic Geology

Geol 336	Mineral Phase Relations (3)
Geol 337	X-ray Diffraction of Materials (3)
Geol 338	Electron Microscopy and Microanalysis (4)
Geol 357	Economic Geology (3)
Geol 372	Principles of Geochemistry (3)

Emphasis on Sedimentary Deposits

Geol 314	Glacial and Quaternary Geology (3)
Geol 319	Stratigraphy and Basin Analysis (3)
Geol 321	Statistical Applications (3)
Geol 327	Genesis of Carbonate Rocks I (1)
Geol 328	Genesis of Carbonate Rocks II (2)
Geol 358	Sedimentary Petrology (4)

Other coherent groups of courses that meet the specific objectives of the individual student may be selected with the approval of the faculty adviser.

Recommended Sequence of Science Courses

freshman year

Geol 21, 22	Principles of Geology and Laboratory (4) **and**
Geol 31	Historical Geology and Stratigraphy (3) **or**
Geol 41	Physical and Historical Geology in the Rocky Mountains (6)
	(summer preceding or following freshman year.)
Math 21, 22	Analytic Geometry and Calculus I and II (8)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Phys 11, 12	Introductory Physics I and Laboratory (5)

sophomore year

Geol 123	Structural Geology (3)
Geol 133	Introductory Mineralogy and Petrology (3)
Geol 111	Computer Applications (1)
Math 23	Analytic Geometry and Calculus III (4)
Phys 21, 22	Introductory Physics II and Laboratory (5)
Chem 31	Chemical Equilibria in Aqueous Systems (3)

junior year

Geol 312	Geomorphology (3)
Geol 313	Sedimentology (3)
Geol 333	Crystallography (3)
Geol 334	Petrology and Petrography (4)
Biol 21, 22	Principles of Biology and Laboratory (4)
Mat 210 or Chem 187	Metallurgical Thermodynamics (3) **or** Physical Chemistry I (3)

summer following junior year

Geol 341	Field Geology (6)

senior year

Geol 301	Introduction to Geophysics (3)
Geol 311	Paleontology (3)
	five professional electives (15)

B.A. in Geological Sciences

A total of 121 credit hours is required.

college and university requirements (44 credit hours)

Engl 1	Composition and Literature (3)
Engl 2, 10, 14 or 16	Composition and Literature: Fiction, Drama, Poetry (3)

distribution requirements:
Preliminary Humanities and Social Science (12)
Upper Class Requirements in Humanities and Social Science (20)
Foreign language or cultures (6)

collateral sciences (19-21 credit hours)

Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Biol 21, 22	Principles of Biology and Laboratory (4) **or**
Biol 133	Invertebrate Zoology (3)
Phys 11, 12	Introductory Physics I and Laboratory (5)

one follow-up course in any of the above fields (3)

CSc 11	Introduction to Structured Programming (3) **or**
CSc 17	Structured Programming and Data Structures (4)

mathematics (9-12 credits)

Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12) **or**
Math 41, 43, 44	BMSS Calculus I, Linear Algebra and Calculus II (9)

geology (31 credit hours)

Geol 21, 22	Principles of Geology and Introductory Geology Laboratory (4) **and**
Geol 31	Historical Geology and Stratigraphy (3) **or**
Geol 41	Physical and Historical Geology in the Rocky Mountains (6)
Geol 123	Structural Geology (3)
Geol 133	Introductory Mineralogy and Petrology (3)
Geol 341	Field Geology (6)
	Geology electives (12)

free electives (13-17 credits)

Recommended Sequence of Science Courses for the B.A. Degree

freshman year

Geol 21, 22	Principles of Geology and Introductory Geology Laboratory (4) **and**
Geol 31	Historical Geology and Stratigraphy (3) **or**
Geol 41	Physical and Historical Geology in the Rocky Mountains (6)
	(summer preceding or following freshman year.)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Math 21, 22	Analytic Geometry and Calculus I and II (8) **or**
Math 41, 43	BMSS Calculus I and Linear Algebra (6)

sophomore year

Geol 123	Structural Geology (3)
Geol 133	Introductory Mineralogy and Petrology (3)
Biol 21, 22	Principles of Biology and Laboratory (4) **or**
Biol 133	Invertebrate Zoology (3)
Math 23	Analytic Geometry and Calculus III (4) **or**
Math 44	BMSS Calculus II (3)

one follow-up course in physics, chemistry, or biology

junior year

CSc 11	Introduction to Structured Programming (3) **or**
CSc 17	Structured Programming and Data Structures (4)
	geology electives(6)

summer following junior year

Geol 341	Field Geology (6)

senior year

	geology electives(6)

Geology Minor

A minor in geological sciences may be achieved by completing the following requirements:

Geol 21, 22	Principles of Geology and Introductory Geology Laboratory (4) **and**
Geol 31	Historical Geology and Stratigraphy (3) **or**
Geol 41	Physical and Historical Geology in the Rocky Mountains (6)
Geol 123	Structural Geology (3)
Geol 133	Introductory Mineralogy and Petrology (3)
	geology elective on 300-level (3)

Combined B.A. or B.S. and M.S. Program in Geological Sciences

The department of geological sciences offers a combined bachelor of arts or bachelor of science and master of science program. Students working toward the bachelor of arts or the bachelor of science in geological sciences who are enrolled in this program are permitted to take courses that apply toward the master of science degree during their senior year. During the student's senior year, the normal undergraduate tuition will cover the costs of all courses taken, including those that are taken for graduate credit.

After receiving the bachelor's degree, students registered in the program may acquire, if eligible for admission to The Graduate School, full-time graduate status, and, as such, they may apply for appointment to a teaching or research assistantship or graduate fellowship.

The program is designed for those students who, upon completing the junior year and the field camp requirement, need less than thirty credit hours to complete work for the bachelor's degree. To be accepted into the program, students should have a superior record of academic performance.

Application for admission to the program should be made no later than the beginning of the first semester of the senior year and must be approved by the department faculty and the dean of The Graduate School. The application must include: a tentative master of science program approved by the department's director of graduate studies, and a roster, also approved by the department's director of graduate studies, showing which courses taken during the senior year apply toward the bachelor's degree and which courses apply toward the master's degree. No more than fifteen credit hours per semester may be rostered. A total of 150 credit hours are required for the combined bachelor of arts—master of science program. All of the normal requirements for each degree as outlined must be fulfilled.

Students enrolled in this program should make application for admission to full-time graduate status after completing the first semester of the senior year.

Program in Civil Engineering and Geological Sciences

The department of geological sciences, in conjunction with the department of civil engineering, administers a five-year program in geological engineering that leads to a bachelor of science degree in civil engineering and a bachelor of science degree in geological sciences. This is described under Civil Engineering and Geological Sciences.

Undergraduate Courses

5. Introduction to Gemology (3)
Physical and chemical properties of natural and synthetic gems and crystals of technical importance. Their mode of occurrence as minerals, crystal structure, synthesis methods and non-destructive methods of identification and characterization. Laboratory work will include the determination of diagnostic optical properties, identification by x-ray diffraction methods, and an introduction to analytical scanning electron microscopy. Sclar

11. Environmental Geology (3) fall-spring
Analysis of the dynamic interaction of geologic processes and human activities. Catastrophic geologic processes, resource limitations and development, pollution of geologic systems, environmental legislation, engineering case studies. Evenson

21. Principles of Geology (3) fall-spring
Fundamental concepts of geology; the composition, structure, and development of the earth; processes of geological change. Lectures and field trip.

22. Introductory Geology Laboratory (1) fall-spring
Recommended laboratory given concurrently with Geol 21. Study of rocks and minerals, rock structures, land forms. Prerequisite: Geol 21 previously or concurrently.

31. Historical Geology and Stratigraphy (3) spring
Origin and evolution of the earth and its parts: continents, ocean basins, hydropshere, and atmosphere; origin and evolution of life. Stratigraphic correlation, faces change, breaks in the record, paleogeographic and paleoenvironmental reconstruction. Lectures and laboratory work. Prerequisite: Geol 21 or 101.

41. Physical and Historical Geology in the Rocky Mountains (6) summer
Six-week field course taught in Wyoming and Idaho. Morning and evening lectures combined with afternoon field exercises. See Geol 21, 22, and 31 for course content. See Geol 341 for location details. Prerequisite: consent of chairman. Evenson and Myers

63. Introduction to Oceanography (3) spring
A survey of the physical, chemical, biological, and geological nature of the oceans. Prerequisite: one year of science (biology, chemistry, geology or physics). Carson

101. Geology for Engineers (3) fall
A study of the materials that make up the earth, the physical, chemical, and environmental history that they relate, and the processes that act to change them. Designed primarily for upperclass science and engineering majors. Lectures and laboratory. Myers

111. Computer Applications (1) fall
The use of computers in the solution of geological problems. Introduction to Fortran; the use of published and available programs.

123. Structural Geology (3) fall
The application of basic concepts of stress and strain and experimental data to study of the developments of faults, folds, and other deformaional structures in the earth's crust. Introduction to the large-scale problems of geotectonics. Prerequisite: Geol 21 or 101. Anastasio

133. Introductory Mineralogy and Petrology (3) fall
Principles of crystallography, mineralogy, and petrology; megascopioc study, identification, and description of common minerals and rocks. Lectures and laboratory. Prerequisite: Geol 21 or 101, Chem 21. Sclar

191. (Biol 191, Chem 193) Environmental Science Seminar (1) fall-spring
Seminar on current problems and developments in environmental science. May be repeated for credit. Prerequisite: sophomore standing. Evenson

281. Geological Research (1-3) fall
Independent investigation of a special problem in the field, laboratory, or library. Prerequisite: consent of chairperson.

282. Geological Research (1-3) spring
Independent investigation of a special problem in the field, laboratory, or library. Prerequisite: consent of chairperson.

For Advanced Undergraduates and Graduate Students

301. Introduction to Geophysics (3) fall
Application of physical principles to solution of crustal and near-surface geologic problems; reflection and refraction seismology, gravity, magnetic and electrical methods. Prerequisite: Math 21, Phys 21, and Geol 21 or 101. Kodama

302. Physics of the Earth (3) spring
Application of physical principles to the earth: origin, geochronology, heat generation and flux, seismology, gravity, magnetism and tectonics. Prerequisite: Math 21, Phys 21. Kodama

306. Geophysical Field Techniques (3) spring
Geophysical field investigation in an area of geological interest. Theory and application of seismic, gravity, magnetism, and electrical methods; data collection, interpetation, and a written report. Individual assignments of a geophysical field in an area of geological interest. Prerequisite: Geol 301 or consent of department chairperson. Kodama

310. Introduction to Plate Tectonics (3) fall
Theory of plate tectonics with emphasis on plate geometry, geophysical relationships and geological consequences. Letures and laboratory. Prerequisite: Geol 21 and 22 or 101, and Physics 21. Kodama

311. Paleontology (3) spring
Morphology of invertebrate fossils, their use in interpreting geologic history; evolution of the faunas and floras. Lectures and laboratory work.

312. Geomorphology (3) spring
Sytematic study of the origin, evolution, and distribution of the earth's topographic features, land forms analyzed in terms of chemical and physical processes responsible for their development. Lectures and required field trips. Prerequisite: Geol 21 or 101. Evenson

313. Sedimentology (3) fall
The processes that control weathering, transportation, and deposition of sediments; the characteristics of sediments and environments of deposition. Lectures and laboratory. Carson

314. Glacial and Quaternary Geology (3) fall
Study of the origin, distribution, and movement of present and past glaciers. Special emphasis on glacial land forms and deposits, quaternary stratigraphy and dating techniques, periglacial phenomena, and Pleistocene environments. Lectures and required field trips. Prerequisite: Geol 21 or 101 or consent of department chairperson. Evenson

317. (Biol 317) Evolution (3)
The origin of species and higher categories with emphasis on animals. Isolating mechanisms, population structure, rates of evolution, extinction. Prerequisite: two semesters of biology or consent of department chairperson.

319. Stratigraphy and Basin Analysis (3) spring
Ancient sedimentary basins: use of surface and subsurface methods of stratigraphic analysis in paleoenvironmental and paleogeographic reconstruction. Facies and facies change,

tectonics and sedimentation, paleocurrent patterns, correlation, sedimentary sequences and cycles; and stratigraphic nomenclature. Prerequisite: Geol 31.

320. Advanced Computer Applications (1-3) spring
Independent investigation of special problems utilizing computer techniques. Prerequisite: Geol 111 or consent of the department chairperson.

321. Statistical Applications (3) fall
Statistical models applicable to geological, geochemical, and geophysical field and laboratory studies. Analysis of variance, applications of the chi-square distribution, analysis of covariance, linear, nonlinear and multiple regression, and distribution-free methods. Carson

323. Geophysics of Plate Tectonics (2) fall
Seminar on geophysical topics in plate tectonics: geometry, seismology, magnetism, gravity, driving mechanism, heat flow. Prerequisite: Geol 123 and Phys 21. Kodama

327. Genesis of Carbonate Rocks I (1) fall
Seminar on the geology and biology of modern and ancient carbonate environments: biology and ecology of major carbonate producing organisms; origin, deposition, lithification and classification of carbonate sediments. Student-faculty seminars and discussions. Evenson

328. Genesis of Carbonate Rocks II (2) spring
Field studies carried out in intersemester period (January) in Florida Keys on modern and ancient carbonate environments: ecology and geology of reef-building corals, calcareous algae, and other carbonate-producing organisms in beach, reef, lagoonal, and traditional environments. Team research projects and reports. Evenson

333. Crystallography (3) fall
Fundamentals of crystallography and crystal structure; patterns and symmetries, symmetry notations, crystal morphologies and internal structure, principles of crystal chemistry. The anisotropy of crystalline materials with special reference to crystal optics. Lectures and laboratory. Prerequisite: Geol 133, previously or concurrently. Simpson

334. Petrology and Petrography (4) spring
Evolution of rocks and their distribution in space and time; Microscopic study of rocks. Lectures, laboratory work, and field trips. Prerequisite: Geol 333. Myers

336. Mineral Phase Relations (3) spring
Principles of phase equilibria; unicomponent and multicomponent condensed systems and multicomponent systems with volatile phases. The application of phase relation studies to mineralogical and geological problems. Prerequisite: Geol 333. Lectures and laboratory. Simpson

337. (Chem 337, Mat 333) X-ray Diffraction of Materials (3) fall
Emphasis on materials characterization with computer-controlled powder diffractometers. Specific topics include x-ray spectroscopy, crystallographic notation, orientation of single crystals, preferred orientations in polycrystals, crystallite size measurement, phase identification, quantitative analysis of crystalline phases, and stress measurement. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisite: consent of department chairperson. Lyman

338. (Mat 334) Electron Microscopy and Microanalysis (4) fall
Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM) conventional transmission (TEM) and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chairperson. Williams, Lyman

341. Field Geology (6) summer
Field study and geologic mapping of sedimentary, igneous, metamorphic, and glacial deposits in the Rock Mountains of northwestern Wyoming, and southeastern Idaho. Additional short studies in the Badlands and Black Hills of South Dakota, the Grand Tetons, Yellowstone Park, Craters of the Moon Park, and other areas in the Rocky Mountain region. Six weeks in the field. Summer session. Prerequisite: consent of the department chairperson. Graduate credit not given for this course. Evenson, Myers

344. Structural Evolution of North America (3) spring
Structural elements of North America and their geological evolution within the framework of global tectonics. Prerequisite: Geol 21 and 22 or 101, 31, and 123.

346. Case Histories in Engineering Geology (3) spring
Methods of geological investigation at engineering sites. Assessing suitability of a proposed site, acquiring geological information for proper engineering design, and recognizing potential geotechnical problems during and after construction. Prerequisite: Geol 21 and 22 or 101. Myers

351. Petroleum Geology (3)
Origin, migration, and accumulation of petroleum and natural gas; general principles of exploration and production. Prerequisite: Geol 123 and Geol 313 previously or concurrently.

352. Applied Mineralogy (3)
Methods and approaches to the solution of industrial and environmental problems employing modern mineralogical techniques, especially transmitted-and incident-light polarizing microscopy and X-ray powder diffraction. Case histories of interest to geologists, chemists, ceramists, chemical, metallurgical, and mineral engineers, environmental engineers, and materials scientists. Lectures and laboratory. Prerequisite: Geol 333 or consent of the department chairperson. Sclar

355. Soil Genesis (3) fall
A geologic approach to the genesis, classification and application of pedology. Weathering of parent materials; chemistry of soils; geologic, biologic, and climate controls on soil formation; geologic and engineering geologic applications of soils. Field and laboratory investigations will acquaint the student with modern analytic techniques. Two lectures and one laboratory/discussion per week. Prerequisite: Geol 313 or consent of the department chairperson. Evenson, Carson, Myers

356. Ground Water (3) fall
The geology and geochemistry of ground water. Techniques used in prospecting for ground water, ground water law, management and conservation, evaluation and planning. Prerequisite: Chem 21, 22, Geol 123. Myers

357. Economic Geology (3) spring
The formation of mineral deposits and the occurrence and characteristics of deposits of economic importance. Includes metals, nonmetals and fuels. Lectures, laboratory work and inspection trips. Prerequisite: Geol 21. Simpson

358. Sedimentary Petrology (4) spring
Origin, structures, and occurrence of sedimentary facies. Characteristics of alluvial, glacial, desert, lacustrine, deltaic, neritic, and pelagic deposition. Petrography of facies as an indicator of source, depositional environment, and tectonic setting. Lectures, laboratory, and field trips. Prerequisites: Geol 313 or equivalent, and Geol 333. Carson

372. Principles of Geochemistry (3) spring
Synthesis of the geological, chemical, physical, and astronomical observations regarding the geochemical evolution

of the earth, its internal constitution, and the physico-chemical processes which modify the crust. Crystal-chemical controls on the abundance of the elements and pressure studies of geochemical significance. Shock metamorphism as a geochemical process on the surface of the earth, moon and planets. Sclar

For Graduate Students

The graduate program in geological sciences is directed principally toward the study of geologic processes. Candidates for the master's degree receive instruction in most fields of geology and are expected to take courses in appropriate collateral fields of science. Graduate students working toward the doctorate specialize in one field of geoscience.

Research is an important part of the graduate program. In general, students are encouraged to choose research problems that for their solution require the use of integrated laboratory and field studies.

Candidates for the master of science degree are required to complete a thesis (six credit hours) that must be presented in the form specified by The Graduate School. The research for and writing of the thesis will be done under the direction of the thesis director who must be a member of the department faculty. The thesis director and two other members will constitute the thesis committee for the master of science candidate. Students who enter the graduate program with a bachelor of science or bachelor of arts degree in geology and who wish to qualify for admission to candidacy for the doctor of philosophy degree must take the departmental qualifying examination prior to the end of the fourth semester. Those who enter the program with a master of science degree must take the qualifying examination prior to the close of their second semester. Candidates entering the program from a discipline other than geoscience will be advised by the faculty when to take the qualifying examination.

Candidates for the doctor of philosophy degree must demonstrate through examination a thorough reading knowledge of one foreign language, generally French, German, or Russian.

Other requirements for graduate degrees are listed in The Graduate School section.

Special departmental research facilities of interest include: Philips APD-3600 automated X-ray powder diffractometer; Philips AXS automated X-ray fluorescence spectrometer, Debye-Scherrer X-ray powder cameras; complete petrographic and incident-light microscopy facilities; hydrothermal apparatus for experimental mineralogy; belt-type ultra-high-pressure apparatus for upper mantle studies; paleomagnetism laboratory with a Molspin spinner magnetometer, a 2-Axis CTF Cryogenic Rock Magnetometer, a Schonstedt tumbling AF demagnetizer, and a Schonstedt thermal demagnetizer; Particle Data computer-based particle-size analyzer; rapid sediment analyzer; Bison shallow refraction seismic unit and Bison shallow resistivity apparatus; master Wordon gravimeter; Geometrics portable proton precession magnetometer; standard equipment for field mapping.

Lehigh houses a station of the Pennsylvania Seismic Network that is equipped with a short-period vertical seismometer. Three wells are also located on campus as an *in situ* groundwater laboratory. Students perform a variety of pump tests, geochemical sampling, and down-hole geophysical determinations at this facility.

The following major analytical facilities are available on campus to students and staff of the department: fully automated JEOL 733 electron microprobe, Philips 300 electron microscope completely equipped for transmission and diffraction, ETEC scanning electron microscope with nondispersive analysis capability, Philips EM400, XTEM/STEM analytical electron microscope equipped for quantitative X-ray microanalysis and electron energy-loss spectroscopy; and Perkin Elmer double-beam infrared spectrophotometer.

405. The Earth's Magnetism (3) spring
Terrestrial magnetism, rock magnetism, history of the geomagnetic field, spherical harmonics, and the interpretation of magnetic anomalies. Prerequisite: Phys 21. Kodama

407. Seismology (3) fall
Basic seismological concepts: design and characteristics of seismometers; interpretation of seismograms; ray paths, body and surface waves, surface wave dispersion, earth structure, and free oscillations of the earth. Prerequisite: Math 23 and Phys 21. Kodama

411. Micropaleontology (3)
Classification, evolution, biometrics and paleoecology; study of fossil and modern populations and assemblages. Lectures and laboratories. Prerequisite: Geol 311.

413. Advanced Topics in Sedimentology (1-3)
Study of the origin, dispersal, deposition, and diagenesis of sediments and sedimentary rocks. May be repeated for credit. Prerequisite: Geol 313. Carson

417. Sedimentary Petrography (3)
The theory and application of petrographic methods in the study and classification of sedimentary rocks. Prerequisite: Geol 334.

419. Sedimentary Basin Analysis (1)
Seminar on the use of directional features, petrographic variations, and other primary physical properties of sedimentary rock that make possible reconstruction of ancient sedimentary basins and sedimentary dispersal systems within such basins. May be repeated for credit.

421. Global Tectonics (3) fall
Topics include upper mantle composition and configuration, interrelations between the earth's crust and upper mantle, geophysical data related to hypotheses in global tectonics, continental drift and the plate model. Seminars and lectures.

422. Regional Tectonics (3) spring
Concepts of global tectonics as applied to the geology of specific areas of the earth's crust. The tectonics of the Alpine-Himalayan chain, Rockies, Caledonides, Appalachian, coast ranges, and African Rift system are among subjects considered. Seminars and lectures.

423. Sedimentary Geochemistry (3)
Processes controlling the distribution of elements in sediments and sedimentary rocks. Lectures, discussions, occasional laboratory exercises, and field trips. Simpson

424. Advanced Structural Geology (3) alternate years
The theory and application of analytical methods in the study of rock deformation; experimental deformation, petrofabric analysis; statistical field methods.

425. Seminar on Tectonics (1)
Seminar on contemporary topics in tectonics. May be repeated for credit. Myers

435. Advanced Mineralogy (3)
Topics of contemporary interest in mineralogy. Simpson

436. Advanced Mineralogy (3) offered as required
Similar to Geol 435. May be elected separately. Simpson

437. Advanced Igneous Petrology (3) alternate years
Origin of the diversity of igneous rocks as revealed by field and laboratory studies. Lectures, laboratory and field trips. Sclar

438. Advanced Metamorphic Petrology (3) alternate years
Processes involved in the transformation of rock masses under high pressure and temperature. Problems of the deep crust and upper mantle. Lectures, laboratory and field trips.

439. Seminar on Petrology (1)
Critical review and assessment of current literature on major topics in petrology. May be repeated for credit. Sclar

442. Advanced Glacial Geology (3)
Seminar on advanced topics in glacial geology; review of classic and contemporary literature. Topics include dynamics of glacier movement, glacial landforms and deposits, glacial stratigraphy. Field trips. Prerequisite: Geol 314 or consent of the department chairperson. Evenson

444. (Biol 444) Multivariate Analysis (3) spring
The strategy of the applications of multivariate analysis techniques to problems in geology and biology. Analysis of larger data matrices by factor analysis, cluster analysis, discriminant function analysis, ordination and related techniques. Examples from both geology and biology. Prerequisite: Geol 111 and 321 or approved equivalents.

446. Advanced Geomorphology (3)
Seminar on advanced topics in geomorphology. Field trips. Prerequisite: Geol 312 or consent of the department chairperson. Evenson

454. Genesis of Metalliferous Deposits (3) alternate years
Petrological concepts regarding the origin of metalliferous ore deposits. Laboratory includes ore-mineral synthesis, ore microscopy, and electron microprobe analysis of ores. Field examination of ore deposits at operating mines. Sclar

455. Advanced Geochemistry (3)
Processes controlling the abundance and distribution of elements. Kinetics and mass balances, stable and radioactive isotopes and partitioning of elements. Lectures, seminars and occasional laboratory exercises. Simpson

456. Advanced Topics in Economic Geology (3)
Modern concepts bearing on the nature and origin of ore deposits. Lectures, seminars, field trips. Simpson

461. Marine Geology (3) alternate years
Geology of the margins and the floors of the oceans. Carson

462. Paleoecology (3)
Reconstruction of paleoenvironments based on principles of paleoecology and sedimentary petrology. Prerequisite: Geol 311 and 313. Parks

471. High-Pressure Petrology (3)
High-pressure phase transformations, phase equilibria, and melting phenomena in multicomponent systems of petrological importance as applied to problems of the deep crust and upper mantle in the pressure range 15 to 150 kilobars at temperatures to 1500 degrees C. Effect of water as a free phase at high pressure. Lectures and laboratories. Sclar

472. Solution Geochemistry (3)
The processes of solution, transport, and deposition under hydrothermal conditions. Simpson

480. (Biol 480) Marine Science Seminar (1)
An advanced interdisciplinary seminar on various problems of marine sciences, with visiting speakers and student presentations.

481. Geological Investigation (1-6) fall-spring
Research on a special problem; field, laboratory, or library study; report required. Credit above three hours granted only when a different problem is undertaken.

482. Geological Investigation (1-6) fall-spring
Similar to Geol 481. Credit above three hours granted only when a different problem is undertaken.

490. Special Topics (1-6)
An extensive study of topics not covered in more general courses.

491. Special Topics (1-6)
Similar to Geol 490. May be elected separately.

Geophysics

Kenneth P. Kodama, associate professor of geophysics, *director.*

Geophysics is the branch of the earth sciences in which physical principles are used to understand the subsurface geology and history of the earth. Geophysical methods are important both in the search for energy and mineral resources and in the delineation of groundwater supplies and the sources of their pollution. On a global scale geophysics has allowed us to unravel the history of continental drift and better understand the plate tectonic model. The program is designed to provide the background needed for graduate work in geophysics or the preparation for employment in the petroleum industry or geophysical consulting firms.

college and university requirements (36 credits)

Engl 1	Composition and Literature (3)
Engl 2, 10, 14, 16	Composition & Literature (3)
	electives (30 credit hours)

Elective courses are nonprofessional courses designed to give the student a broad understanding in traditional and contemporary fields of thought outside of natural science and mathematics. The courses are chosen by the student. The elective program includes a large number of courses broadly distributed among the various areas of the humanities and the social sciences.

major program (92-97 credit hours)

mathematics (18 credit hours)

Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
Math 23	Analytic Geometry and Calculus III (4)
Math 205	Linear Methods (3)
Math 322	Methods of Applied Analysis I (3)

collateral sciences (8 credit hours)

Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Mat 210	Metallurgical Thermodynamics (3) **or**
Phys 340	Thermal Physics (3)

physics (22 credit hours)

Phys 11	Introductory Physics I (4)
Phys 12	Introductory Physics Laboratory I (1)
Phys 21	Introductory Physics II (4)
Phys 22	Introductory Physics Laboratory II (1)
Phys 190	Electronics (3)
Phys 212	Electricity and Magnetism I (3)
Phys 213	Electricity and Magnetism II (3)
Phys 215	Classical Mechanics I (3)

geology (32 credit hours)

Geol 21	Principles of Geology (3)
Geol 22	Introductory Geology Laboratory (1)
Geol 31	Historical Geology and Stratigraphy (3)
Geol 111	Computer Applications (1)
Geol 123	Structural Geology (3)
Geol 133	Introductory Mineralogy and Petrology (3)
Geol 301	Introduction to Geophysics (3)
Geol 302	Physics of the Earth (3)
Geol 313	Sedimentology (3)
Geol 333	Crystallography (3)
Geol 341	Field Geology (6)

approved professional electives (12-17 credit hours)
Any courses approved by the adviser may be used to satisfy this requirement. The following are especially recommended:

Geol 310	Introduction to Plate Tectonics (3)
Chem 31	Chemical Equilibria in Aqueous Systems (3)

Geol 63	Introduction to Oceanography (3)
Geol 306	Geophysical Field Techniques (3)
Geol 319	Stratigraphy and Basin Analysis (3)
Geol 321	Statistical Applications (3)
Geol 334	Petrology and Petrography (4)
Geol 336	Mineral Phase Relations (3)
Geol 372	Principles of Geochemistry (3)
Math 323	Methods of Applied Analysis II (3)
Math 208	Complex Variables (3)
Math 309	Theory of Probability (3)
Math 320	Ordinary Differential Equations (3)
Math 344	Linear and Integer Programming (3)
ME 231	Fluid Mechanics (3)
Mat 92	Structure and Properties of Materials (3)
Phys 31	Introduction to Quantum Mechanics (3)
Phys 216	Classical Mechanics II (3)
Phys 340	Thermal Physics (3)
Phys 352	Modern Optics (3)
Phys 261	Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phys 190	Electronics (3)
Phys 363	Physics of Solids (3)
Phys 365	Physics of Fluids (3)

German

See listings under Modern Foreign Languages.

Government

Professors. Howard R. Whitcomb, Ph.D. (S.U.N.Y. at Albany), *chairperson;* Donald D. Barry, Ph.D. (Syracuse), *University Professor;* Frank T. Colon, Ph.D. (Pittsburgh); Laura Katz Olson, Ph.D. (Colorado).
Associate professors. Richard K. Matthews, Ph.D. (Toronto); Edward P. Morgan, Ph.D. (Brandeis).
Assistant professors. Jean C. Oi, Ph.D. (Michigan); Jean K. Rosales, Ph.D. (Texas).
Instructor. Albert H. Wurth, Jr., M.A. (Southern Illinois).

The major in government is designed to promote understanding of political ideas, institutions and processes and to develop skills in analyzing and evaluating political problems.

A balanced program within the discipline, one that exposes the student to various areas of inquiry in American institutions and political processes as well as in the comparative and philosophical perspectives of political analysis, has been the way in which the goals of the major program generally have been achieved. While the major program outlined below will prove adequate for most student needs, it may be that because of some special factors such as late transfer or unusual interests and/or abilities the outlined program does not accommodate some students. In that case the students may, in consultation with their adviser, develop a major program that in their judgment will more adequately fulfill those needs.

The faculty adviser to the student majoring in the government department is designated by the department. The adviser consults with the student and approves the major program. The adviser attempts to help the student relate courses offered by the department to the student's educational goals. The adviser also may act as a resource for the students, and may suggest courses in other disciplines, language courses, and courses in research techniques that may be of benefit.

A variety of experiential opportunities are available to undergraduates majoring in government. The department, for example, offers annually a "Government and Law Internship" that includes opportunities for internship placements in either local government, private agencies or law offices. Students are also encouraged to apply for off-campus, internship opportunities, e.g., American University's Washington Semester Program.

Completion of the government major is considered suitable training for the undergraduate who wishes to go on to law school, to become a social science teacher, or to work as a governmental official, party or civic leader, public affairs commentator, or staff member of a government research bureau. In addition, the business sector continues to provide opportunities in areas such as banking, insurance, and marketing for bachelor of arts graduates with training in the social sciences. Graduate study is advisable for students contemplating certain careers: college teaching, research, or public management, for example.

The four core courses are required. Individual exceptions may be made, for good reasons, by the major adviser with the approval of the department chairman.

Major Requirements

Govt 1	American Political System (3)
Govt 3	Comparative Politics (3)
Govt 21	Introduction to Research Methods (3)
Govt 102	Modern Political Heritage (3)

electives

Seven courses in the following two fields:

American politics, public law and interdisciplinary

Govt 77	Urban Politics (3)
Govt 111	The Politics of Environment and Natural Resources (3)
Govt 174	Political Parties and Elections (3)
Govt 179	The Politics of Women (3)
Govt 302	Comparative State Politics (3)
Govt 306	Public Policy Process (3)
Govt 317	The American Presidency (3)
Govt 327	Socialization and the Political System (3)
Govt 330	Politics of the 1960's (3)
Govt 331	Government and Law Internship (3)
Govt 333	The Social Psychology of Politics (3)
Govt 351	Constitutional Law (3)
Govt 352	Civil Rights (3)
Govt 354	Administrative Law (3)
Govt 355	Public Personnel (3)
Govt 359	U.S. Congress (3)
Govt 360	Public Administration (3)

Political theory and comparative politics

Govt 101	Classical Political Heritage (3)
Govt 106	Chinese Politics (3)
Govt 108	Japanese Politics (3)
Govt 161	The Soviet Political System (3)
Govt 171	Democracy (3)
Govt 308	Ideologies in World Affairs (3)
Govt 318	Communist Political Systems (3)
Govt 320	Peasants and Revolution (3)
Govt 322	Politics of Developing Nations (3)
Govt 324	Political Systems in Transition (3)
Govt 325	International Political Economy (3)
Govt 364	Issues in Contemporary Political Philosophy (3)
Govt 367	American Political Thought (3)
Govt 368	Political Economy (3)

Government Minor

The minor consists of three of the four core courses listed above (Govt 1, Govt 3, Govt 21 and Govt 102) plus any two other government courses.

Public Administration Minor

The minor consists of Govt 1 and Govt 360 plus three other courses chosen in consultation with the adviser for a total of fifteen credit hours.

Undergraduate Courses

1. American Political System (3) fall-spring
Constitutional principles; organization and operation of the national government; the party system, citizenship, and civil rights.

3. Comparative Politics (3) fall-spring
The political systems of foreign countries; approaches to the study of comparative politics.

21. Introduction to Research Methods (3) fall-spring
The research techniques of political science including research design, statistical and nonstatistical analysis, and computer applications.

77. Urban Politics (3)
The structure and processes of city government in the United States; city-state and federal-city relaionships; the problems of metropolitan areas; political machines and community power structures; the urban politics of municipal reform; city planning and urban renewal. Colon

101. Classical Political Heritage (3)
Significant political theorists from Plato to modern times. Matthews

102. Modern Political Heritage (3) fall-spring
Continuation of Govt 101, Classical political heritage. Utilitarianism, liberalism, socialism, idealism, positivism, etc. Matthews

106. Chinese Politics (3)
Causes and character of the Chinese communist revolution, process and problems of Socialist transformation, nature of authority and compliance under socialism, and changes in the post-Mao state. Oi

108. Japanese Politics (3)
Legacy of traditional Japan; contemporary political parties and interest groups; government intervention and economic decision making; and the clientelist nature of Japanese politics. Oi

111. The Politics of Environment and Natural Resources (3)
A survey of the major environmental, resource, energy and population problems of modern society, focusing on the United States. The politics of man's relationship with nature, the political problems of ecological scarcity and public goods, and the response of the American political system to environmental issues. Wurth

161. The Soviet Political System (3)
The roles of the communist Party, the Council of Ministers, the Supreme Soviet and othe governmental and social organizations in governing the USSR. Barry

171. Democracy (3)
Theory and practice of democratic government in selected countries.

174. Political Parties and Elections (3)
Organization, functions, and behavior of parties in the United States; voting behavior, campaigns, and elections. Colon

179. The Politics of Women (3)
Major social and political issues relating to the role of women in American society. Study of other countries will be included for comparative analysis. Olson

For Advanced Undergraduates and Graduate Students

302. Comparative State Politics (3)
Analysis of major questions relating to the role of the states in the American federal systems and their relationship with the national government. Colon

306. Public Policy Process (3)
Power relations and their impacts on selected public policy issues, specifically taxation, housing, environment, poverty, energy, the military, and health. Olson

308. (IR 308) Ideologies in World Affairs (3)
Theories of ideology; nationalism and imperialism; conservatism/liberalism/socialism; Marxism/Leninism/Maoism; fascism and militarism; Third World ideologies; current ideological trends. Wylie

313. Teaching Government (3)
Contemporary issues in the teaching of social studies in public and private schools, including those government decisions that affect the educational environment. The course focuses attention on a specific issue such as urban problems, comparative political systems, ideologies and American political institutions and processes. Designed primarily for secondary school teachers.

314. Workshop in Teaching Government (3)
Individual research projects contemporary issues and discussion of proposals for curriculum revisions in the public and private schools. Outside speakers will be invited to attend workshop sessions. Must be taken concurrently with Govt 313 when courses are offered together.

317. The American Presidency (3)
Role of the executive in the American political process. Includes an analysis of the historical development, selection process, and scope of executive power. Olson

318. (IR 318) Communist Political Systems (3)
Examination Communist political systems outside the USSR and the operations of nonruling Communist parties.

320. Peasants and Revolution (3)
Comparative study of peasant participation in everyday strategies of survival and resistance and extraordinary events of rebellion and revolution. Case studies: traditional, contemporary, and socialist agrarian states. Countries may vary by semester. Oi

322. (IR 322) Politics of Developing Nations (3)
Theories of political development in non-Western areas; modernization and nation building. Field studies and methods; contributions of related disciplines such as sociology and psychology. Oi

324. Political Systems in Transition (3) spring
The responses of selected non-Communist states to contemporary problems. Topics vary semester by semester. May be repeated for credit with consent of department chairperson.

325. (IR 325) International Political Economy (3)
Development of forms of political management of the world economy since World War II, with emphasis on control of interdependence among the industrialized countries, achievement of equity in relations between developed and developing countries, and reintegration of the centrally planned economies into the international economy.

327. Socialization and the Political System (3)
The social ideological and economic foundations of American politics. Emphasis on supporting institutions-family, schools, and workplace-and processes that foster political attitudes and behavioral patterns. Morgan

330. Politics of the 1960's (3)
Social and political movements of the 1960's from the perspective of the American political tradition. Civil rights, black power, campus protests, Vietnam War policy-making, the anti-war movement, the counter-culture. Morgan

331. Government and Law Internship (3)
Integrated fieldwork and academic study. Internship with government or non-profit agencies, elected officials, or law offices. May be repeated for credit. Prerequisite: consent of the department chairperson.

333. (SPSY 333) The Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective.

351. Constitutional Law (3) fall
The law of the Constitution as expounded by the Supreme Court of the United States. Nature and origins of judicial review, distribution and scope of governmental powers, and economic regulation in a federal system. Detailed consideration of judicial policy decision-making processes. Whitcomb

352. Civil Rights (3) spring
A study of constitutional development in political and civil rights. Freedom of speech and of the press, religious freedom, due process of law and equal protection of the laws. Detailed consideration of constitutional issues concerning criminal procedure and racial discrimination. Whitcomb

354. Administrative Law (3)
The authority, procedures, and methods used by executive agencies in the adminstration of public policy. Analysis of the general problem of adjusting the administrative process to traditional constitutional principles. Barry

355. Public Personnel (3)
Problems in public personnel administration; the civil service and its reform; public employee unionism; due process within the organization; affirmative action; political neutrality of public servants. Barry

359. U.S. Congress (3)
The origins and development of Congress, formal and informal power of legislation and oversight. Party leadership and committees, House and Senate differences, and Congressional relations with the President, the bureaucracy and the Supreme Court.

360. Public Administration (3)
The nature of administration; problems of organization and management; public personnel policies; budgeting and budgetary system; forms of administrative responsibility. Colon

364. Issues in Contemporary Political Philosophy (3)
Selected topics in contemporary political philosophy, such as the Frankfurt school, existentialism, legitimation, authenticity, participatory democracy, and the alleged decline of political philosophy. May be repeated for credit with the consent of the department chairperson. Matthews

367. American Political Thought (3)
A critical examination of American political thought from the founding of the Republic to the present. Writings from Madison, Hamilton, and Jefferson to Emma Goldman, Mary Daly, Malcolm X, Henry Kariel, and others will be discussed.

368. Political Economy (3)
Significance to democratic theory of the concentration of economic power and its interface with the polity.

371. Readings (1-3)
Readings in political science assigned to properly qualified students in consideration of their special interest in particular political institutions and practices. Prerequisite: consent of the departmental chairperson.

372. Readings (1-3)
Continuation of Govt 371. Prerequisite: consent of the department chairperson.

381,382. Special Topics (3)
A seminar on a topic of special interest in a particular political institution process, or policy. Prerequisite: consent of the department chairperson.

For Graduate Students

The department of government offers a graduate program leading to the doctor of arts (no new students are being accepted into the doctor of arts program), the master of public administration, and the master of arts. The applicant for admission is required to demonstrate adequate undergraduate preparation, and may under certain circumstances be asked to submit Graduate Record Examination results.

Master of Arts

The master arts in government is a thirty-credit-hour program that can be accomplished in twelve months by full-time students. A comprehensive examination is required. The student may take twenty-four hours of course work and six hours of thesis or may take all thirty credit hours in course work. A graduate-level course in research methods is required of all candidates for the master of arts degree.

The master of arts program is intended for the student with liberal arts or natural science preparation who has a professional interest in government. The master of arts may be a preparatory step toward doctoral work at another institution or a final degree preparatory for teaching in junior and community colleges or research positions in governmental, institutional or industrial settings.

Master of Public Administration

The master of public administration is a final degree emphasizing career preparation for governmental service. The program is designed to emphasize administration in all levels of governmental service—national, state, urban and municipal—and non-governmental service in quasi-public and academic organizations.

The program consists of four parts:

core curriculum (12 credit hours).
The core curriculum consists of courses in public management, legal foundations of public administration, governmental budgeting, and public policy.

methodology and tools (6 credit hours).
Two methodology courses, one dealing with basic methodological issues and techniques and another with field applications and data analysis, are required. Govt 421 and Govt 463 are designed to fulfill these requirements, but other courses may be substituted with the approval of the adviser. Also, a basic proficiency in accounting is required.

public administration electives (9 credit hours).
These electives, chosen in consultation with an adviser, may include courses from a number of departments such as government, economics, history, management, and social relations.

internship (3 credit hours).
This will be a specially arranged program. If a student has broad practical experience in public service, the internship requirement may be waived at the discretion of the graduate committee. A thesis-level essay is substituted.

The final requirement for the master of public administration is a comprehensive examination.

Doctor of Arts

The doctor of arts program is designed for students holding the bachelor's or master's degree who wish to prepare for a career in college teaching of political science. The major emphasis of the program is on American politics and institutions. Course work is also available across a wide range of other aspects of political science, however. In every respect, the evaluation standards are equal to those of a doctor of philosophy

program. Guidelines developed by the Council of Graduate Schools and American Association of State College and Universities have been followed in planning this program.

The doctor of arts program differs from the doctor of philosophy program in five ways: the requirement of a broader distribution of graduate courses in government; a minor area of study of those students who wish to have bidisciplinary preparation for two-year college teaching; a general examination tailored to the doctor of arts; a nontraditional dissertation aimed at enhancing teaching competence; and supervised internships.

The student entering will follow one of three tracks, depending on whether he or she is: beginning graduate work; transferring up to thirty credit hours for a master of arts in political science; or transferring up to thirty credit hours for a master of arts in a cognate field.

As currently structured, it is possible for the student entering with a bachelor of arts to complete the program in three years of full-time study. The full-time student entering with a master of arts, either in political science or in a cognate field, can complete it in two calendar years.

The doctor of arts program consists of four parts: a core concentration; a concentration in political science; a minor in a cognate field; and a dissertation.

the core curriculum (12 credit hours)
teaching government (3)
research methods (3)
teaching internship (3)
community internship (3)

In addition, it is recommended that doctor of arts students take Psych 411, Interpersonal Awareness.

political science concentration (24-51 credit hours)
The political science core requirements consist of twelve credit hours. Required courses are The American Polity and Theoretical Issues in American Politics. In addition, the student is required to take at least one-graduate seminar from the public administration field and at least one graduate seminar from the area of American government and public law.

From twelve to thirty-nine additional credits in political science (coursework from other departments may be substituted if approved by the adviser) are required. The total number of credits will depend on the student's graduate coursework (including transfer credit) must include at least six credits in political theory and six credits in comparative politics.

The student is expected to register for 400-level courses where appropriate, but may fill out the course work with 300-level courses taken for graduate credit.

Cognate minor (9 credit hours). On the basis of interest and undergraduate education, students are encouraged to select their minor from a wide range of subject areas including both the natural and social sciences.

Students entering Lehigh with a master of arts in a cognate field may be excused from all course work in this area.

Dissertation (9-18 credit hours). The course credit allocated to the dissertation will vary from nine credit hours for the student who transfers with a master of arts in a cognate field, to eighteen credit hours for the student who enters the program with a bachelor of arts degree. Regardless of the credits allocated, the standards for the dissertation are identical.

Examination. Those students entering the doctor of arts program without the master's degree in political science will be required to take a continuing proficiency examination prior to their second year of study.

The general examination is taken prior to the commencement of the student's dissertation. It consists of a major written examination (six hours) on American politics and institutions and a minor written examination (three hours) covering the fields of comparative politics and political theory. An oral examination completes the general examination.

The student is required to defend the completed dissertation before the doctoral committee.

Graduate Courses

403. The American Polity (3)
Integrative overview of the American polity's emphasis on national institutions: presidency, Congress, judiciary, party systems and their interrelations.

405. The Budgetary Process (3)
The public budgetary process: competition among interest groups, policy outcomes, intergovernmental relations, and consequences for policy implementation.

407. American Constitutional Development (3)
The law of the Constitution as expounded by the Supreme Court of the United States. Nature and origins of judicial review, institutional aspects of separation of powers and federalism, economic regulation in a federal system, and political and civil rights. Detailed consideration of judicial policy-making processes and judicial biography. Whitcomb

411. The Legal Foundations of Public Administration (3)
The authority, procedures, and methods used by executive agencies in the administration of public policy and the general problem of adjusting the administrative process to traditional constitutional and legal principles. Barry

413. Modern Political Philosophy (3)
A study of selected modern political philosophers and their continuing effect on politics and political philosophy. Matthews

415. State and Local Government (3)
Comparative state government, urban politics, intergovernmental relations, regional and local government. Colon

416. American Environmental Policy (3)
Formation, implementation and impact of environmental policies in the U.S. An examination of the scope of environmental problems, the development of environment as an issue, the role of interest groups and public opinion, the policy-making process, and the various approaches to implementing environmental policy. Special attention to current issues and administrative approaches and to the distinctive character of environmental protection as a political issue. Wurth

419. Theoretical Issues in American Politics (3)
American contributions to main currents in political philosphy from colonial times to present. Matthews

421. Research Methods (3)
Research approaches, design techniques, statistical and non-statistical analysis, and computer applications.

424. Administrative Theory (3)
Administrative theory and practice in both the public and nonpublic spheres in the United States; model building and field research emphasizing the concepts of public and private administrative systems. Colon

425. Comparative Bureaucratic Systems (3)
Bureaucracies and bureaucrats in Western and non-western political and cultural systems. Their role, power, internal dynamics and personal interactions; problems of policy implementation. Oi

430. Analytical Techniques for Public Administration (3)
Introduction to models, concepts and techniques of decision theory, management science, managerial economies and systems theory. Emphasis on public sector applications.

431. Public Management (3)
The study of bureaucracy and problems of public and nonprofit organization and management; executive leadership; personnel management systems and regulatory administration. Colon

432. Public Policy Process (3)
Impacts of power relationships on selected public policy areas such as the military, agriculture, housing, environmental, energy, poverty, health, and taxation. May be repeated for credit. Olson

434. Internship (3)
Internship in private or public agency. May be repeated for credit.

437. Teaching Internship (3)
Supervised practice teaching at the college level. For doctor of arts students.

451. Comparative Politics (3)
Theory and concepts in comparative politics. Analysis of applications in studies of Western and non-Western political systems.

463. Methods of Urban Policy Analysis (3)
Analysis of selected topics in urban or state/local policy. Applied research projects include computer-based statistical analysis. Prerequisite: Govt 421 or consent of the department chairperson. Morgan

471. Seminar in Teaching Government (3)
Theories and techniques of instruction, learning, evaluation, instructional design and innovation in the teaching of government. Prerequisite: doctor of arts candidacy or permission of the department chairperson.

481. Special Topics (3)
Individual inquiry into some problem of government. Reading, field work, and other appropriate techniques of investigation. Conferences and reports. May be repeated for credit.

482. Special Topics (3)
Continuation of Govt 481.

Greek

See listings under Classics.

Hebrew

Modern Hebrew is taught in the department of Modern Foreign Languages. Biblical Hebrew is associated with the department of Religion Studies. Consult the relevant entry in this section.

History

Professors. Joseph A. Dowling, Ph.D. (N.Y.U.), *chairman, distinguished professor;* G. Mark Ellis, Ph.D. (Harvard); John H. Ellis, Ph.D. (Tulane); Lawrence H. Leder, Ph.D. (N.Y.U.); James S. Saeger, Ph.D. (Ohio State); William G. Shade, Ph.D. (Wayne State); Roger D. Simon, Ph.D. (Wisconsin); C. Leon Tipton, Ph.D. (Southern California).
Associate professors. Michael Baylor, Ph.D. (Stanford); Ian P.H. Duffy, D.Phil. (Oxford, England).
Assistant professor. James Reid, Ph.D. (U.C.L.A.).
Adjunct professors. Curtis Keim, Ph.D. (Indiana); Winfred Kohls, Ph.D. (Berkeley).
Research Associate. William L. Quay, Ph.D. (Lehigh).

History is the study of human activities. As such, it encompasses not only events and public policy, but the whole sweep of cultural achievements—religion and philosophy, literature and art, economic and social life. Some of the most influential thinkers and public people of our time (Toynbee, Kennan, Churchill, Kennedy, among others) have studied contemporary problems by viewing the forces in the past that have shaped our world.

Students take courses in three culture areas, examining major developments in each in terms of cause and effect, the historians' main concern. These courses provide training in research, analysis of historical problems, and formulation of historical judgments, as well as in writing. History majors have the foundation for law school, government service, journalism, teaching, and graduate study.

Honors study in history is by invitation of the department in the student's junior year. The student is required to attain an average of 3.25 in history courses, and must demonstrate a special competence in history. Those interested in honors work are urged to consult the department chairman early in their junior year.

Honors students in history may plan special programs, including more in-depth study of two culture areas rather than three. They enroll for three hours credit of unrostered history as part of their thirty-nine credit hours and complete in that course an honors thesis.

Distribution Requirements

The major totals thirty-nine credit hours.

A history major meets the following distribution requirements:
Hist. 11, 12; and a maximum of nine hours in courses below 100; minimum of twelve hours in courses numbered above 200 not including Hist. 201 and 395; Hist. 201 or 395; maximum of eighteen hours of courses from any one group, and minimum of three hours from each group listed below.

Group A courses

Hist 7	The Machine in America (3)
Hist 8	History of Medicine in America (3)
Hist 9	Survey of American History I (3)
Hist 10	Survey of American History II (3)
Hist 53	Religion and the American Experience (3)
Hist 119	Colonial America (3)
Hist 120	Revolutionary America (3)
Hist 124	Women in America (3)
Hist 131	The Black Experience in America (3)
Hist 135	United States, 1789-1840 (3)
Hist 136	United States, 1840-1877 (3)
Hist 137	United States, 1877-1920 (3)
Hist 138	United States, 1920 to Present (3)
Hist 207	Seminar in the History of Technology (3)
Hist 231	American Diplomatic History (3)
Hist 245	Victorian Britain (3)
Hist 246	Great Britain in the 20th Century (3)
Hist 260	American Constitutional and Legal History (3)
Hist 310	American Military History (3)
Hist 325	American Social History, 1607-1877 (3)
Hist 326	American Social History Since 1877 (3)
Hist 327	American Intellectual History (3)
Hist 328	American Intellectual History (3)
Hist 333	American Urban History to 1885 (3)
Hist 334	American Urban History, 1880 to Present (3)
Hist 338	Psychohistory (3)
Hist 339	Topics in American Public Health (3)
Hist 340	Topics in American Medicine (3)

Group B courses

Hist 11	Survey of European History I (3)
Hist 12	Survey of European History II (3)
Hist 15	English History (3)
Hist 16	English History (3)
Hist 21	Ancient History (3)
Hist 22	Ancient History (3)
Hist 149	The Barbarian West (3)
Hist 150	Medieval Civilization (3)
Hist 154	The Holocaust: History and Meaning (3)

Hist 157	The Renaissance and Reformation (3)
Hist 158	Early Modern Europe (3)
Hist 159	Modern Europe (3)
Hist 160	Modern Europe (3)
Hist 243	English History, 1471-1660 (3)
Hist 244	English History 1660-1789 (3)
Hist 261	A History of Russia to 1855 (3)
Hist 262	A History of Russia, 1855 to Present (3)
Hist 263	Early Modern Germany, 1618-1848 (3)
Hist 264	Modern Germany, 1848 to Present (3)
Hist 267	The Iberian Peninsula (3)
Hist 337	History of Medical Thought (3)
Hist 355	European Cultural History I (3)
Hist 356	European Cultural History II (3)
Hist 357	English Constitutional and Legal History to 1783 (3)

Group C courses

Hist 4	Chinese Civilization (3)
Hist 5	African Civilizations (3)
Hist 49	History of Latin America (3)
Hist 50	History of Latin America (3)
Hist 61	Survey of Middle Eastern History I (3)
Hist 62	Survey of Middle Eastern History II (3)
Hist 171	History of Southern Africa (3)
Hist 172	History of West Africa (3)
Hist 173	Topics in Middle Eastern History (3)
Hist 175	Modern China (3)
Hist 176	Topics in East Asian History (3)
Hist 265	Mexico and the Caribbean (3)
Hist 266	Argentina, Brazil and Chile (3)
Hist 368	Seminar in Latin American History (3)

Hist 51, 300, 371, 372, or provisional courses will be placed in one of the above groups in accordance with their contents and emphases.

History majors are encouraged to enroll in courses in economics, English and American literature, government, international relations, philosophy, psychology, religion studies, and social relations. Students intending to do graduate work should acquire a reading knowledge of at least one foreign language, choosing languages appropriate to their area of concentration.

Minor Programs

A student may establish a minor program in history that covers either a geographical, topical, or chronological interest (American, European, technological and medical, or twentieth century history, to mention a few possibilities). Each student's minor program is prepared in consultation with the chairman of the history department. Advanced placement credit may not be used for the minor program. The minor totals at least fifteen hours and conforms to the following pattern:

* six hours in courses numbered below 100
* maximum of six hours in 100 level courses
* minimum of three hours in courses numbered above 200

Undergraduate Courses in History

Petitions are required for Freshmen to take 100-level or higher courses, and for Sophomores to take 200-level or higher courses.

1. Course of Civilizations (3) fall
Civilizations in the East, West, and Africa from earliest times to 1700. Haight

2. Course of Civilizations (3) spring
Civilizations in the East, West, and Africa from 1700 to the present. Haight

4. Chinese Civilization (3)
Imperial China: Thought, literature, and fine arts related to politics and society. The fate of the traditional heritage in the twentieth century.

5. African Civilizations (3)
Sub-Saharan Africa to present. Anthropological examination of traditional societies, chronology of indigenous African developments. Keim

7. The Machine in America (3)
American technology since colonial times. Changes in techniques and organization of processing, manufacturing, transportation and construction: consideration of social, cultural, and economic impact. Simon

8. History of Medicine in America (3)
Institutional development of the American medical profession. John Ellis

9. Survey of American History I (3) fall
Social, economic, cultural and political institutions through Reconstruction, emphasizing their effects on public policy and culture.

10. Survey of American History II (3) spring
American culture, politics, and society from the late nineteenth century to the present, emphasizing the impact of industrialization.

11. Survey of European History I (3) fall
Development of Western civilization from decline of the Roman Empire to the 17th century. End of the ancient world, origins and growth of medieval civilization, the Renaissance and Reformation. Baylor

12. Survey of European History II (3) spring
European culture and society from the 17th century to the present. Rise of scientific thought and the state system of the *ancien régime*, impact of the French and industrial revolutions, nationalism and liberalism, and two world wars and the end of European supremacy. Baylor

15. English History (3) fall
The history of England to 1688. The origins of representative government, the development of English social institutions, the unification of England, and the Renaissance and Reformation in England. Duffy

16. English History (3) spring
English political and social institutions from 1688 to the present. The evolution of parliamentary government, the rise of modern parties, the industrial revolution, and recent social philosophies. Duffy

21. (Clss 21) Ancient History (3) fall
The development of civilization from paleolithic times to the world empire of Alexander the Great. The social, economic, religious, philosophic, artistic, and literary development of the ancient world; the origin of political institutions. Phillips

22. (Clss 22) Ancient History (3) spring
Continuation of Greek 21, The Hellenistic Age. Rome from its origin to 395 A.D. Phillips

49. History of Latin America (3) fall
Spanish and Portuguese colonization of America and the struggles for independence, preceded by a brief view of the ancient American civilizations and Iberian backgrounds. Saeger

50. History of Latin America (3) spring
Continuation of Hist 49. The development of the Latin American nations in the nineteenth and twentieth centuries. Saeger

51. Freshman Seminar (3)
An intensive analysis of a particular period, problem or area of history, emphasizing readings, discussions and reports, The topics and instructor vary each semester. Open by invitation to students with advanced placement credit in history or equivalent background, or upon application to the chairman of the department.

53. (Rel 53) Religion and the American Experience (3) fall
The historical development of major religious groups in this country from colonial times to the present. Their place in social and political life, and the impact of the national experience upon them. Emphasis on religious freedom and pluralism, and the church-state relationship. A. Eckardt

61. Survey of Middle Eastern History I (3) fall
Social, economic, cultural, and political history of Islam from Mohammed to the mid-18th century. Reid

62. Survey of Middle Eastern History II (3) spring
Continuation of History 61, emphasizing the formation of Islamic states and political events of the 20th century. Reid

103. (Rel 103) Christianity I: Early and Medieval (3) fall
Historical and theological investigations of Orthodox and Catholic traditions. Issues of doctrine, authority, community and liturgy. Speller

119. Colonial America (3) fall
Founding and growth of colonies in North America through circa 1750. Attention will be paid to motives behind European expansion as well as to developments in the colonies. Leder

120. Revolutionary America (3) spring
American political, economic and cultural development from the mid-eighteenth century through the adoption of the Federal Constitution. Leder

124. Women in America (3)
Roles of Women in American Society from Colonial to present times: attitudes toward women, female sexuality, women's work, and feminism. Shade

131. The Black Experience in America (3)
Black subculture in America from the colonial period to the present, emphasizing the struggle for emancipation and equal rights. Topics include: racialism, slavery, Reconstruction, urbanization protest movements, and the 'Second Reconstruction.' Shade

135. United States, 1789-1840 (3)
The American political system from the Constitution through Jacksonianism. Special emphasis upon the first and second party systems and the democratization of American political culture. Shade

136. United States, 1840-1877 (3)
Civil War and Reconstruction, emphasizing the causes of the Civil War, its impact upon American society and politics, and problems of postwar reconstruction. Shade

137. United States, 1877-1920 (3)
Political, economic and social responses to industrial America. The rise of the Populist and Progressive movements, coming of World War I, and postwar developments. John Ellis

138. United States, 1920 to Present (3)
American institutions in the modern era, emphasizing critical changes of the 1920s, the Crash of 1929, the New Deal, World War II, and later political, social and economic events. Dowling

145. (STS 145) Introduction To the History of Science (3)
The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the seventeenth century.

149. The Barbarian West (3) fall
Merger of Greco-Roman, Germanic and Christian institutions and culture in Western Europe to mid-eleventh century. Evolution of the church, feudalism and manorialism, and the foundations of the Carolingian and Holy Roman empires. Tipton

150. Medieval Civilization (3) spring
Formation and development of western culture to about 1400. Rise of universities and towns, legal development and origins of representative government, origins of nation-states, scholasticism and decline of the medieval church. Tipton

154. (Rel 154) The Holocaust: History and Meaning (3) spring
The Nazi Holocaust in its historical, political and religious setting. Emphasis upon the moral, cultural and theological issues raised by the Holocaust. A. Eckardt

157. (Rel 157) The Renaissance and Reformation (3) fall
Transition from medieval to early modern society: decline of medieval civilization; political, social and cultural changes of the Renaissance; development of Protestantism and impact on European politics and culture. Baylor

158. Early Modern Europe (3) spring
Transformation of European civilization from the 30 Years War to the outbreak of the French Revolution. Origins and development of the European state system; absolutism; commercial expansion and competition for empire; science; the Enlightenment; impact on European culture and politics. Baylor

159. Modern Europe (3) fall
Revolutions and reactions in Western Europe from 1789 to 1870. The rise and spread of liberalism and the origins of socialism. Duffy

160. Modern Europe (3) spring
Contemporary Europe; the origins and consequences of two world wars; the rise of revolutionary governments in Italy, Germany and Russia. Duffy

171. History of Southern Africa (3)
Africa south of the Zambesi especially after arrival of Europeans. Portuguese contact with the Bakongo, effect of missionaries, conflicts between British and Boers, exploitation of minerals, apartheid, American policy, and socialism in Angola and Mozambique. Keim

172. History of West Africa (3)
Crop and animal domestication, rise and fall of western Sudan and forest empires, slavery and slave trade, the Fulani Jihads, legitimate trade, colonialism, nationalism, and uncertainty since independence. Keim

173. Topics in Middle Eastern History (3)
Problems in major societies of the contemporary Middle East. Reid

175. Modern China (3)
Transformation in nineteenth and twentieth centuries. Effect of Western forces, disintegration of traditional Confucian state and society, emergence of modern nationalism, twentieth-century revolutions and rise of the People's republic.

176. Topics in East Asian History (3)
Topics in major societies of East Asia.

For Advanced Undergraduates And Graduate Students

201. Historical Perspectives (3) spring
Methodologies and interpretations of Western historians from ancient times to the present. G. Mark Ellis

207. Seminar in the History of Technology (3)
Readings and research in the history of technology, the engineering profession, and engineering education in America. Students will pursue topics of individual interest around some general theme. Prerequisite: Hist 7 or consent of department chairman. Simon

215. (Clss 215) Decline and Fall of the Roman Empire (3)
Political, social, and economic history of the Roman Empire, A.D. 117-A.D. 565. Romanization of the provinces, diffusion

of Christianity, and special attention to transformation to medieval period. Includes readings in translation of primary sources. Phillips

231. American Diplomatic History (3) fall
Late 18th-century diplomatic ideas, their development and application through the 19th century, and their transformation in the 20th century as a result of changing needs and responsibilities. Leder

243. English History, 1471-1660 (3) fall
England under the Tudor monarchy and the problems facing its successors culminating in the civil wars and Interregnum. Political, economic, intellectual and religious developments of the period. G. Mark Ellis

244. English History 1660-1789 (3) spring
Constitutional monarchy from the Stuart Restoration to the French Revolution. English civilization in an age of oligarchy, especially the political, social, economic and intellectual sectors. G. Mark Ellis

245. Victorian Britain (3) fall
Development of democracy, liberalism, religious ferment, industrialization, class conflict, socialism, and empire in Victorian Britain.

246. Great Britain in the 20th Century (3) spring
Effects of world wars, loss of great power status, economic decline, social conflict, welfare state, modern political parties, Irish problem on 20th century Britain.

260. American Constitutional and Legal History (3) fall
Adoption of the federal constitution and its modification and expansion: Anglo-American legal tradition and its transformation. Leder

261. A History of Russia to 1855 (3) fall
Major cultural, social, and political traditions of the Russian people. Kohls

262. A History of Russia, 1855 to Present (3) spring
The Great Reforms, collapse of Tsarist absolutism, revolution of 1917, and formulation and consolidation of the Soviet dictatorship. Kohls

263. Early Modern Germany, 1618-1848 (3) fall
Germany from the 30 Years War to the Revolution of 1848. Origins and development of absolutism, transformation of German society and thought, Austro-Prussian dualism, impact of the French Revolution and defeat of early liberalism. Baylor

264. Modern Germany, 1848 to Present (3) spring
German nationalism and Prussian unification, socio-economic and cultural change in the Second Empire, First World War and the Weimar Republic, origins and growth of fascism, the Third Reich and post-totalitarian Germany. Baylor

265. Mexico and the Caribbean (3)
Emphasis on Mexico and Cuba from the era of Bourbon reforms through the wars of independence to the twentieth century revolutions. Saeger

266. Argentina, Brazil and Chile (3)
Eighteenth-century Spanish imperial readjustments, independence, the emergence of new societies, twentieth-century extremist movements, and the problems of developing nations. Saeger

267. The Iberian Peninsula (3)
Rise and fall of Spain and Portugal as European and colonial great powers in the early modern period; their development after the Industrial Revolution; emphasis on Spanish Civil War (1936-39). Saeger

310. American Military History (3) spring
The American military tradition from colonial times to the present. America's wars and the development and operation of military institutions within the political, economic, ideological, and technological milieu of American society. Saeger

325. (Soc 325) American Social History, 1607-1877 (3) fall
Social change from early agrarian communities to beginnings of industrialism, emphasizing socio-economic class, family structure, and treatment of women and minority groups. Shade

326. (Soc 326) American Social History Since 1877 (3) spring
Changing role of women, minorities, and the family during the industrial era. Development of the modern class structure and the impact of the welfare state. Simon

327. American Intellectual History (3) fall
Development of political, social and religious ideas in America from the colonial period to the Civil War. Dowling

328. American Intellectual History (3) spring
Economic, political and religious thought in industrial America, 1860 to present. Dowling

333. American Urban History to 1885 (3) fall
Planning and design of colonial and frontier cities. Impact of transportation innovations and industrialization, emergence of a national system of cities. Internal problems of early industrial cities: housing, transportation, public health, crime, social mobility. Simon

334. American Urban History, 1880 to Present (3) spring
Physical expansion of the industrial city and its relationship to current urban problems. Suburbanization, development of the central business district, reforms in housing and public health, rise of ghettoes, emergence of the city planning profession and the idea of 'new town,' impact of the New Deal and 'urban renewal.' Simon

337. History of Medical Thought (3)
From prehistory to present: shamanism and healing, Greco-Roman medicine, Paracelsus and Harvey, and the germ theory of disease. John Ellis

338. Psychohistory (3) spring
Uses of psychology in history and biography; exploration of problems of methodolgy, verification of evidence, conceptual frameworks and theories of personality; potentialities and limitations of psychological investigation as an historical technique. Dowling

339. Topics in American Public Health (3)
Reading and research on topics in the history of the American public health movement. Prerequisite: Hist 8. J.H. Ellis

340. Topics in American Medicine (3)
Reading and research on topics in the history of American medicine. Prerequisite: Hist 8. J.H. Ellis

355. (Rel 355) European Cultural History I (3) fall
Major developments in European culture from the late Middle Ages through the 17th century. Late scholasticism, humanism and the Renaissance, varieties of Protestantism, origins of modern science. Baylor

356. European Cultural History II (3) spring
Transformation of European culture from the 18th century to the present. The Enlightenment, cultural impact of the French and industrial revolutions, romanticism and ideologies of the 19th century, contemporary European thought. Baylor

357. English Constitutional and Legal History to 1783 (3) spring
Origins and development of government, administration and law from Anglo-Saxon times to 1783, emphasizing common-law institutions, practices and procedures. Duffy

368. Seminar in Latin American History (3) Saeger
Readings and individual investigation of selected topics.

371. Special Topics in History (1-3)
Intensive study in an area of history not adequately covered in currently listed offerings. The course may be administered as a reading program or otherwise as may seem best to meet the needs of students of unusual ability and adequate preparation. Prerequisite: consent of the department chairman.

372. Special Topics in History (1-3)
Continuation of History 371. Prerequisite: consent of the department chairperson.

395. Quantitative Methods in Historical Studies (3)
Historical uses and methods of quantitative analysis, including the application of descriptive statistics, statistical inference, and computer technology to a variety of problems drawn from European , American and Latin American history. Shade

For Graduate Students

Linderman Library is especially rich in materials for advanced study and research in history, and the department of history offers program leading to master of arts and doctor of philosophy degrees. Graduate programs provide intensive and specialized study, and the policy of limited enrollment permits close relations between faculty and students.

Admission to graduate study in history is competitive and dependent upon the applicant's undergraduate preparation and record, recommendations, and Graduate Record Examination scores. Besides general requirements for the Graduate School, the following special requirements apply to graduate study in history.

Master of Arts

There are two masters programs. Under plan I, a candidate may earn the degree by successfully completing twenty-four hours of approved course work and submitting a satisfactory thesis. Those continuing toward a doctorate elect plan I. Candidates declaring plan II do not write a thesis, but take thirty hours of course work in and pass examinations in two fields chosen from American, British, European and Latin American history. Candidates in either plan are required to maintain a 3.0 average in all graduate work and to take at least one research seminar.

Doctor of Philosophy

Candidates for the doctor of philosophy in history must maintain a 3.25 history average and a 3.0 over-all average on all graduate work taken at Lehigh or elsewhere. Students entering with a master's degree take a qualifying examination before beginning their second semester at Lehigh. During the second semester, doctoral students select four history fields and one outside field and prepare themselves for written and oral examinations in those fields. An original dissertation is required and may be written only in a primary field.

Primary fields. Primary fields are Colonial America, nineteenth-Century America, twentieth-Century America, and history of technology.

Other fields. Other fields of specialization are Medieval-Renaissance, Modern Europe to 1789, Modern Europe Since 1789, and Latin America.

Language requirements. The qualifying examination in one language must be passed before beginning course work beyond the master's degree in order that the language may be used in doctoral course work. The candidate's special committee, appointed by the chairman of the department, will designate any additional languages for the student, if needed. Languages normally chosen are French, Spanish, Italian, German or Russian. Graduate-level competence in statistical methods and computer application are acceptable as replacement for a foreign language. All graduate majors take Hist 401 and either 404 or 405. All Ph.D. candidates must take 18 hours of directed readings and two research seminars.

More detailed regulations are given in the *Handbook for Graduate Work in History,* available in the history department office.

401. Methods in Historical Research (3) fall
Techniques of research in history: training in the critical handling of documentary materials, in measuring the value of evidence, and in formal presentation of the results of research. Required of all graduate students in history. Tipton

404. Historiography: Europe (3)
The approach, methods and interpretations of the leading historians of Europe.

405. Historiography: America (3)
The approach, methods and interpretations of the leading historians of America.

442. Readings in American History (3)
Study in small groups under the guidance of a faculty member of the literature of a particular period, problem, or aspect of American history. May be repeated for credit with permission of the department chairman.

443. Readings in English History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of English history. May be repeated for credit with permission of the department chairman.

444. Readings in Latin American History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem, or area of Latin American history. May be repeated for credit with permission of the department chairman.

447. Readings in European History (3)
Study in small groups, under the guidance of a faculty member, of the literature of a particular period, problem or aspect of European history. May be repeated for credit with permission of the department chairman.

452. Research in American History (3)
An intensive research seminar on a phase of American history. May be repeated for credit with permission of the department chairman.

453. Research in English History (3)
An intensive research seminar on a phase of English history. May be repeated for credit with permission of the department chairman.

454. Research in Latin American History (3)
An intensive research seminar on a phase of Latin American history. May be repeated for credit with permission of the department chairman.

457. Research in European History (3)
An intensive research seminar on phase of European history. May be repeated for credit with permission of the department chairman.

Industrial Engineering

Professors. George E. Kane, M.S. (Lehigh), *chairperson;* Mikell P. Groover, Ph.D. (Lehigh); Wallace J. Richardson, M.S. (Purdue); John C. Wiginton, Ph.D. (Carnegie Mellon); Emory W. Zimmers, Jr., Ph.D. (Lehigh).
Associate professors. John W. Adams, Ph.D. (North Carolina); Nicholas G. Odrey, Ph.D. (Penn State); Louis J. Plebani, Ph.D. (Lehigh); George R. Wilson, Ph.D. (Penn State).
Assistant professor. G. Sathyanarayanan, Ph.D. (Michigan Tech).
Instructors. Robert H. Storer, M.S. (Georgia Tech); Gregory L. Tonkay, B.S. (Penn State).

The curriculum is designed with the principal aim of industrial engineering in view, which is the design, improvement, and installation of integrated systems of people, materials, and equipment for operations by the application of the principles of the mathematical, physical, and behavioral sciences.

Throughout the program there is an integrated series or sequence in the major field that includes not only basic and fundamental courses but specialized courses as well, in the fields of production planning and control, quality control, computer-integrated manufacturing, production engineering, information systems, robotics, and operations research. These specialized courses reflect the impact of recent developments in operations research, information processing, and manufacturing systems.

Career Opportunities

There is a growing tendency on the part of industries to select young people from their engineering departments for managerial positions. Because of this the industrial engineering courses are oriented to the principles of scientific management to enable the industrial engineering graduate to accept and succeed in these opportunities.

It is the aim of the industrial engineering program to develop the potential manager for either the manufacturing or service industries as well as the government agency, a graduate well grounded in the fundamentals of science, trained in the principles of engineering analysis and design, and thus prepared to practice the profession of industrial engineering.

Physical Facilities

The manufacturing technology laboratory affords an opportunity to students for gaining understanding and skills in manufacturing processes, experimental design, collection of data, manufacturing systems, and instrumentation calibration.

The computer-integrated manufacturing (CIM) laboratory presents the student with an opportunity to use a mini-computer and microprocessors for data collection, process design, and process control.

The information systems laboratory serves the student by presenting opportunities in interactive programming, data processing, and data base systems.

The microprocessor laboratory serves the student by providing an opportunity to gain understanding and design skill in the application of microprocessors to industrial engineering situations.

An interdisciplinary robotics laboratory provides students with the opportunity to gain first-hand experience with the various types of robots and to gain skill in planning their use.

The work systems laboratory affords the opportunity to students to analyze and plan human activities at both individual work stations and in the monitoring of multiple machine stations. This is accomplished in part through the use of microprocessor-driven simulators.

Considerable use is made of the university Computing Center facilities in all levels of course work.

Special Programs

Electives within the industrial engineering curriculum. The industrial engineering curriculum offers an extensive program of electives that permits the student to shape a program of study that reflects personal interests. The over-all program of electives is comprised of:

15 credit hours of engineering science electives
9 credit hours of advanced industrial engineering electives
15 credit hours of general studies electives
6 credit hours of free electives

Use of electives to emphasize an area within industrial engineering. Lehigh's industrial engineering department emphasizes four areas: information systems, manufacturing systems, operations research, and operations management. Students may choose their electives to emphasize one area. Examples of using the elective program for this purpose are as follows:

Information Systems Emphasis

suggested course work

engineering science (15 credit hours)

CSc 33	Principles of Computer Engineering (4)
CSc 261	Discrete Structures (3)
ECE 315	Principles of Computer Software (3)
CE 121	Mechanics of Fluids (3)
ME 104	Thermodynamics I (3)

IE electives (9 credit hours)

IE 307	Advanced Systems Analysis and Design (3)
IE 310	Database Analysis and Design (3)
IE 345	Manufacturing Information Systems (3)

General Studies (15 credit hours)

Phil 13	Practical Logic (3)
Jour 123	Basic Science and Technical Writing (3)
Jour 311	Science and Technical Writing (3)
Anth 131	Science, Technology and Society (3)
Psyc 1	Introduction to Psychology (3)

free electives (6 credit hours)

Spch 31	Business and Professional Speaking (3)
IE 334	Organizational Planning and Control (3) **or**
1E 341	Data Communication Systems Analysis and Design (3)

Manufacturing Systems Emphasis

suggested course work

engineering science (15 credit hours)

Mech 1, 11	Statics and Mechanics of Materials (6)
Mat 213	Materials Systems Analysis (3)
CE 121	Mechanics of Fluids (3)
ME 104	Thermodynamics I (3)

IE electives (9 credit hours)

1E 324	Industrial Robotics (3)
IE 340	Production Engineering (3)
IE 342	Computer Integrated Manufacturing (3) **or**
1E 343	Microprocessor Systems in IE (3)

General Studies (15 credit hours)

Anth 131	Science, Technology and Society (3)
Psyc 1	Introduction to Psychology (3)
Eco 105	Intermediate Microeconomic Analysis (3)
Eco 335	Labor Economics (3)
Hist 7	The Machine in America (3)

free electives (6 credit hours)

Spch 31	Business and Professional Speaking (3)
IE 332	Product Quality (3)

Operations Research Emphasis

suggested course work

engineering science (15 credit hours)

CSc 261	Discrete Structures (3)
CE 121	Mechanics of Fluids (3)
Mech 1, 11	Statics and Mechanics of Materials (6)
ME 104	Thermodynamics I (3)

IE electives (9 credit hours)

1E 305	Simulation (3)
1E 317	Probabilistic Models II (3)
1E 318	Deterministic Models II (3)

General Studies (15 credit hours)

Phil 13	Practical Logic (3)
Phil 214	Logical Theory (3)
Anth 131	Science, Technology and Society (3)
Hist 7	The Machine in America (3)
Eco 105	Intermediate Microeconomic Analysis (3)

free electives (6 credit hours)

Spch 31	Business and Professional Speaking (3)
IE 307	Advanced Systems Analysis and Design (3)

Operations Management Emphasis

suggested course work

engineering science (15 credit hours)

Mech 1, 11	Statics and Mechanics of Materials (6)
Mat 213	Materials Systems Analysis (3)
CE 121	Mechanics of Fluids (3)
ME 104	Thermodynamics I (3)

IE electives (9 credit hours)

IE 305	Simulation (3).
IE 342	Computer Integrated Manufacturing (3)
IE 345	Manufacturing Information Systems (3)

General Studies (15 credit hours)

Eco 105	Intermediate Microeconomic Analysis (3)
Eco 229	Money and Banking (3)
Eco 335	Labor Economics (3)
Hist 7	The Machine in America (3)
Psyc 1	Introduction to Psychology (3)

free electives (6 credit hours)

Spch 31	Business and Professional Speaking (3)
Fin 225	Business Finance (3)

Options Through Electives

The following section shows how use of electives can help students achieve education goals.

To pursue a technical minor. Students may elect to use their electives to obtain a technical minor. A technical minor requires a minimum of fifteen credit hours. The engineering minors available to industrial engineering majors include molecular biophysics, chemical processing, computers, fluid mechanics and solid mechanics. The courses taken to satisfy the minor are part of the elective program and do not require an academic overload.

To pursue a nontechnical minor. Students may choose to pursue nontechnical minors ranging from classics to economics. A nontechnical minor requires a minimum of fifteen credit hours. The courses taken to satisfy the nontechnical minor are part of the elective program and do not require an academic overload.

Industrial Engineering/Master of Business Administration program. Students in the Industrial Engineering Curriculum may pursue a special IE/MBA program by completing the 42 hours of courses listed below in the suggested sequence while completing their major in one of the BS programs in the college during their first four years. At the end of this period, if they are admitted to the Graduate School, they may be granted their MBA degree upon completion of an additional 39 hours of course work. This can usually be accomplished in two regular semesters and two summer sessions.

All courses listed below under Other Required Courses must have a grade of B- or better in order to be credited toward the MBA program.

The following comprise the required courses during the four years in the college:

required background courses

Eco 1	Economics (4)
Math 21	Analytic Geometry and Calculus I (4)
Math 22	Analytic Geometry and Calculus II (4)
IE 224	Information Systems Analysis and Design (3)

other required courses

IE 121	Applied Engineering Statistics (3)
Acct 51	Introduction to Financial Accounting (3) (Free Elective)
Acct 52	Introduction to Managerial Accounting (3) (Substituted for Acct 108)
Eco 105	Intermediate Microeconomic Analysis (3) (General Studies Elective)
Eco 119	Intermediate Macroeconomic Analysis (3) (General Studies Elective)
Acct 234	Cost Accounting (3) (Free Elective)
IE 221	Operations Research - Probabilistic Models (3)
Law 201	Legal Environment of Business (3) (Free Elective
Eco 229	Money and Banking (3) (General Studies Elective)

Students who do not take Acct 52 and Acct 324 as undergraduates will be required to take Acct 413 as part of their MBA course work.

Major Requirements

To be effective with the Class of 1988

freshman year see page 36

sophomore year, first semester (16 credit hours)

IE 111	Engineering Probability and Statistics (3)
IE 112	Computer Graphics (1)
Math 23	Analytic Geometry and Calculus III (4)
Phys 21, 22	Introductory Physics II and Laboratory (5)
	engineering science elective (3)

sophomore year, second semester (17 credit hours)

IE 121	Applied Engineering Statistics (3)
IE 122	Software Tools (1)
IE 124	Engineering Economy and Decision Analysis (3)
	engineering science elective (3)
Mat 63	Engineering Materials and Processes (3)
Eco 1	Economics (4)

junior year, first semester (16 credit hours)

IE 115	Fundamentals of Modern Manufacturing (3)
IE 116	Manufacturing Laboratory (1)
IE 221	Operations Research - Probabilistic Models (3)
Math 205	Linear Methods (3)
Acct 108	Fundamentals of Accounting (3)
	engineering science elective (3)

junior year, second semester (17 credit hours)

IE 131	Work Systems and Facilities Planning (3)
IE 132	Work Systems and Facilities Planning Laboratory (1)
IE 222	Operations Research - Deterministic Models (3)
IE 224	Information Systems Analysis and Design (3)
ECE 81	Principles of Electrical Engineering (4)
	general studies elective (3)

summer
IE 100 Industrial Employment (0)

senior year, first semester (18 credit hours)
IE 251 Production and Inventory Control (3)
IE elective (3)
general studies elective (6)
engineering science elective (3)
elective (3)*

senior year, second semester (18 credit hours)
IE 154 Senior Project (3)
IE electives (6)
general studies elective (3)
engineering science elective (3)
elective (3)*

For engineering science electives, see the approved list in the industrial engineering office.
*please refer to description of normal program, page 36.

Undergraduate Courses

100. Industrial Employment (0)
Usually following the junior year, students in the industrial engineering curriculum are required to do a minimum of eight weeks of practical work, preferably in the field they plan to follow after graduation. A report is required. Prerequisite: Sophomore standing.

111. Engineering Probability and Statistics (3) fall
Random variables, probability models and functions, and expected values. Statistical inference, estimation, hypothesis testing, and goodness of fit. Prerequisite: Math 22.

112. Computer Graphics (1) fall
Introduction to interactive graphics and construction of multi-view representations in two- and three- dimensional space. Applications in industrial engineering. Prerequisite: Sophomore standing in industrial engineering, Engr. 1.

115. Fundamentals of Modern Manufacturing (3) fall
Study of modern production methods. Machining and other metal working processes, electrical and electronics manufacturing, and nontraditional processing. Introduction to automation, numerical control, and industrial robots. Prerequisite: Mat 63.

116. Manufacturing Laboratory (1) fall
Laboratory exercises and experiments in manufacturing processes and systems. Prerequisite: IE 115, either previously or concurrently.

121. Applied Engineering Statistics (3) spring
The applicaton of statistical techniques to solve industrial problems. Topics include regression and correlation, analysis of variance, quality control, and reliability. Prerequisite: IE 111 or Math 231.

122. Software Tools (1) spring
Introduction to application software tools, including word processing, spreadsheets, and statistical packages. Problems for solution will be drawn from other courses in the sophomore program. Prerequisites: Engr. 1; IE 121, 124 concurrently.

124. Engineering Economy and Decision Analysis (3) spring
Economic analysis of engineering projects; interest rate factors, methods of evaluation, depreciation, replacement, breakeven analysis, after-tax analysis. Decision-making under certainty and risk. Prerequisite: IE 111 or Math 231, either previously or concurrently.

131. Work Systems and Facilities Planning (3) spring
Techniques of methods analysis, work measurement, and facilities design. Man-machine systems, assembly systems, operations analysis, time study, predetermined time systems, work sampling, incentive systems, plant layout, and materials handling. Prerequisite: IE 121, either previously or concurrently.

132. Work Systems and Facilities Planning Laboratory (1) spring
Laboratory exercises and projects in methods analysis, operations analysis, plant layout, and related topics. Prerequisite: IE 131, either previously or concurrently.

154. Senior Project (3) fall and spring
The use of industrial engineering techniques to solve a major problem in either a manufacturing or service environment. Problems are sufficiently broad to require the design of a system. Consideration of human factors in the system design. Laboratory. Prerequisite: Senior standing in industrial engineering.

168. Production Analysis (3) fall and spring
A course for the engineering student not majoring in industrial engineering. Engineering economy; application of quantitative methods to facilities analysis and planning, operations planning and control, work measurement and scheduling, and operating systems analysis. Prerequisites: Math 22 or 42; Eco 1.

For Advanced Undergraduates and Graduate Students

221. Operations Research - Probabilistic Models (3) fall
Probabilistic models in operations research. Topics include queueing theory, probabilistic inventory models, Markov analysis, and simulation, including use of a simulation language. Prerequisite: IE 111 or Math 231.

222. Operations Research - Deterministic Models (3) spring
Deterministic models in operations research. Topics include linear programming, integer programming, networks, dynamic programming, and classical optimization, Prerequisite: Math 205.

224. Information Systems Analysis and Design (3) spring
Study of information systems development to include design, implementation, evaluation, and management based on a standard development life cycle methodology. Structured analysis and design techniques are introduced. Prerequisites: Junior standing in Industrial Engineering, IE 122 and Acct 51 or 108.

251. Production and Inventory Control (3) fall
Techniques used in the planning and control of production and inventory systems. Topics include forecasting, inventory models, operations planning, and scheduling. Prerequisite: IE 221, either previously or concurrently, and IE 121, IE 222.

305. Simulation (3)
Applications of discrete and continuous simulation techniques in modeling industrial systems. Simulation using a high level simulation language. Design of simulation experiments. Prerequisites: IE 221 and IE 222.

307. Advanced Systems Analysis and Design (3) spring
Study of advanced techniques and their application in the analysis and design of information systems. Emphasis is placed on tools and techniques used for structured analysis and design, and on prototyping of systems. Prerequisite: IE 224 or 309 or equivalent.

309. Introduction to Information Systems (3) fall
Study of information systems analysis and design with emphasis on management issues. Interfaces between information systems and databases and data communications are examined. Effects of information systems on organizational relationships are considered. Example information system will be designed and implemented. Prerequisite: Engr. 1 or

equivalent. Not available to Industrial Engineering undergraduates.

310. Database Analysis and Design (3) spring
Conceptual analysis of data is considered through data structures and models. Logical design of databases is studied in the context of the relational model of data. Prerequisite: IE 224 or 309 or equivalent.

317. Probabilistic Models II (3)
Study of Markov chains and Markov processes, Poisson process generalizations, renewal theory, and stationary processes. Applications dealing with reliability, discrete time queues, inventory control, risk models, and traffic flow. Autoregressive and moving average models of time series. ARIMA specification and applications to forecasting. Prerequisites: IE 221 and IE 222.

318. Deterministic Models II (3)
Optimization techniques for unconstrained, equality constrained, and inequality constrained problems. Integer programming and dynamic programming applications. Elementary non-linear programming algorithms and applications. Finite calculus and operator methods. Numerical approximations techniques. Prerequisites: IE 221 and IE 222.

321. Experimental Industrial Engineering (1-3)
Experimental projects in selected fields of industrial engineering, approved by the instructor. A written report is required. May be repeated for academic credit.

324. Industrial Robotics (3)
Introduction to robotics technology and applications. Topics include robot anatomy, controls, sensors, programming, work cell design, part handling, welding, and assembly. Laboratory exercises. Prerequisites: Mech 1, Math 205.

332. Product Quality (3)
Inspection for process control and product acceptance. Performance and life tests, increased severity. Evaluation of design in structure, process and performance specifications. Liability, unlikely events. Calibration versus data adjustment, traceability. Quality Assurance organization. Military standards and Federal regulations. Prerequisite: IE 121.

334. Organizational Planning and Control (3) fall
Design of organization and procedures for managing functions of industrial engineering. Analysis and design of resources planning and control, including introduction of change in man-machine systems; manpower management and wage administration. Prerequisite: IE 131 or 168.

340. Production Engineering (3) fall
Develop plans of manufacturing for discrete parts. Product design analysis and engineering materials utilization. Economic analysis of process design alternatives. Introduction to mechanization and automation. Term project. Laboratory. Prerequisite: IE 115.

341. Data Communication Systems Analysis and Design (3)
Study of data communications systems analysis and design to provide a basis for designing, implementing, and managing information systems employing wide and/or local area networks. Prerequisite: IE 224 or 309 or equivalent.

342. Computer Integrated Manufacturing (3) spring
Analysis and design of manufacturing systems using digital computers. Principal topics: computer-aided techniques, group technology, applications of minicomputers to manufacturing systems. Introduction to adaptive control, numerical control, and optimization strategies for discrete parts manufacturing. Term project. Prerequisite: IE 224, IE 115 or equivalent.

343. Microprocessor Systems in IE (3) fall
Fundamentals of microprocessors and microcomputers for industrial engineering applications. Topics include basic digital concepts, microprocessor programming interfacing, data acquisition and system development for timing, counting, decision making and control. Laboratory. Prerequisite: IE 224 and IE 115 or equivalent.

344. Metal Machining Analysis (3) spring
Intensive study of metal cutting emphasizing temperature and energy relationships and their effect on tool life, power requirements and surface finish. Economic balancing of metal cutting variables from application of theory. Lectures and laboratory experiments including designing and conducting an original experiment. Prerequisite: IE 115.

345. Manufacturing Information Systems (3)
This course examines the foundations for information systems required to support the manufacturing function throughout the product life cycle. Students will be exposed to the problems of design, implementation, and management by way of assigned readings, class discussion of cases, and a research project. Prerequisite: IE 224 or IE 309, and 251 or equivalent.

Graduate Programs

Programs leading to the master of science and doctor of philosophy degrees are offered by the department in the following fields: manufacturing systems, information systems, and operations research.

These programs, briefly described, are as follows:

M.S. in Industrial Engineering

The minimum program for the master of science degree consists of twenty-four credit hours of approved course work and completion of a satisfactory thesis.

A master of science program is selected to meet the interests and needs of the student, and courses in other departments for which the student has the prerequisites may be integrated into the major field. Subject to proper approval, nine credit hours of 400-level courses from outside the department may be included among the courses required in the major field. As part of a purposeful major program, collateral courses may be taken in other branches of engineering, mathematics, economics, psychology, and information and computer science.

A comprehensive examination that entails a breadth of knowledge in industrial engineering is required of all candidates for this degree.

M.S. in Management Science

The department and the College of Business and Economics administer an interdisciplinary program leading to a master of science degree in management science. Students are admitted and may enroll in either department for administrative purposes. The minimum program consists of thirty credit hours of approved course work.

M. Eng. in Industrial Engineering

This program of study is for those students whose interests are toward design rather than research. This program will provide opportunity to gain breadth of field by required course work in all areas of study within the department. In addition, a design project is carried out under the supervision of the faculty that further emphasizes breadth of field.

A comprehensive examination that entails a breadth of knowledge in industrial engineering is required of all candidates for this degree.

Ph.D. in Industrial Engineering

This program is organized to meet the individual goals and interests of industrial engineering students who plan to engage in teaching, consulting, or research activities in industrial, governmental, or educational environments.

Each doctoral student is required to demonstrate competency in several broad fields of industrial engineering related to a personal area of interest and prepare, through formal course work and independent study, for examination in

the particular area of specialization by members of the faculty. A dissertation related to the field of specialization is required.

Further information about the doctor of philosophy program is contained in the Graduate School section and in a brochure available from the department.

Areas of Graduate Study

The areas of graduate study and research that are emphasized in the department are as follows:

Operations Research. The operations research program is intended to prepare students to recognize, formulate and solve problems using combinations of analytic methods and techniques. These methods include linear programming, combinatorial optimization, queueing theory and statistics.

There are many settings in which problems solvable by operations research methods are encountered, but those which arise in the context of the manufacturing or service industries are of particular interest at Lehigh. Students can expect to encounter and study challenging and important problems at either the Masters or Ph.D. levels.

Information Systems. Graduate study in information systems includes course work and research in advanced systems analysis and design, advanced manufacturing databases, advanced manufacturing information systems, as well as long-range and strategic planning for information systems. Additional related courses are offered in other departments and colleges. In particular, CSEE offers courses in data communications and artificial intelligence, in both cases with strong emphasis on manufacturing. The graduate business program offers courses on the management and implementation of technology-based systems. The information systems area is supported by a laboratory containing a variety of interconnected configurations of equipment providing extensive support for both MS-DOS and UNIX operating system-based languages and tools.

Manufacturing Systems. Graduate study in manufacturing systems and production engineering involves course work and research in various topics related to manufacturing. These topics include computer integrated manufacturing (CIM), automation and numerical control, robotics, process control, metal machining, material handling, work systems, and production control. Additional related courses are offered in other departments in the College of Engineering and Applied Science. The manufacturing systems area is supported by several departmental laboratories, including the Manufacturing Technology Laboratory, Computer Integrated Manufacturing Laboratory, Robotics Laboratory, Microprocessor Applications Laboratory, and the Work Systems Laboratory.

A related graduate program is the interdisciplinary program in Manufacturing Systems Engineering (MSE), leading to the Master of Science degree. Details about this MSE Program are described elsewhere in this catalog.

The department offers courses during the late afternoon and early evening for the convenience of students who are employed in local industry and are taking graduate work on a part time basis.

405. Special Topics in Industrial Engineering (3)
An intensive study of some field of industrial enginering.

408. (Acct 433) Management of Information Systems (3)
Philosophies and methods for systematic planning, development, and implementation of management information systems. Concepts of information resource management, and strategic and long-range planning of information systems and services. Prerequisite: IE 224 or IE 309 or Acct 311 or equivalent.

409. Data Dependent Systems (3)
Theory and applications of an approach to process modeling, analysis, prediction, and control based on an ordered sequence of observed data. Single or multiple time series are used to obtain scalar or vector difference/differential equations describing a variety of physical and economic systems. Prerequisite: IE 317.

410. Design of Experiments (3)
Experimental procedures for sorting out important causal variables, finding optimum conditions, continuously improving processes, and trouble shooting. Applications to laboratory, pilot plant and factory. Prerequisite: Some statistical background and experimentation in prospect.

411. Networks and Graphs (3)
Applications of graph and network theory to the solution of problems in industrial systems. Topics include: set covering, graph coloring, location of centers, shortest paths, Hamiltonian circuits, and network flows. Prerequisite: IE 318.

415. Manufacturing Management (3)
Analysis of the factors entering into the development of manufacturing management philosophy; decision-making process in areas of organization, planning, operation, and control of manufacturing. Influence of the social, technical, and economic environment upon manufacturing management decisions.

416. Dynamic Programming (3)
The principle of optimality; one-dimensional processes, multi-dimensional processes, LaGrange multiplier technique. Markovian decision processes; applications. Prerequisite: IE 318 or equivalent.

417. Advanced Mathematical Programming (3)
Theory and applications of the extensions of linear programming. Kuhn-Tucker conditions, gradient methods of optimization, simplex-based methods of nonlinear programming, integer programming, branch and bound, zero-one discrete programming, and stochastic programming. Prerequisite: IE 318 or equivalent.

419. Sequencing and Scheduling (3)
Study of sequencing and scheduling problems and models. Specific topics addressed are simple and parallel machine models, flow shop scheduling, analytic and simulation approaches to job shop scheduling, and extensions to resource constrained project scheduling. Prerequisites: IE 318 and IE 251 or equivalents.

424. Robotic Systems and Applications (3)
Detailed analysis for robotic systems in manufacturing. Topics include task planning and decomposition, motion trajectory analysis, conveyor tracking, error detection and recovery, end effector design, and systems integration. Prerequisite: IE 324 or consent of chairperson.

428. Advanced Work Systems (3)
A critical evaluation of methods improvement and work measurement techniques. Emphasis on design of work systems, productivity improvement, and reporting systems to control work. Work sampling, construction of standard data, mathematical models of work systems.

429. Artificial Intelligence in Manufacturing (3)
A variety of topics may be examined including intelligent databases, and design and development of knowledge-based expert systems. Prerequisite: IE 340 or IE 342 or equivalent.

430. (Mgt 430) Management Science Project (3) spring
An analysis of a management problem and design of its solution incorporating management science techniques. An individual written report is required. Recommended to be taken in the last semester of the program.

431. Operations Research Seminar (3)
Extensive study of selected topics in techniques and models of operations research.

433. Manufacturing Engineering Seminar (3)
Extensive study of selected topics in the research and development of manufacturing engineering techniques.

437. Advanced Database Analysis and Design (3)
Intensive treatment of design and application of modern database technology, including information modeling and logical design of databases. Particular emphasis on applications to the manufacturing environment. Prerequisite: IE 310 or equivalent.

438. Advanced Data Communication Systems Analysis and Design (3)
Systematic analysis and design of data communications networks through understanding of the functions and limitations of network building blocks, as well as the factors which affect design. Emphasis on local area networks as applied to the factory environment. Prerequisite: IE 341 or equivalent.

439. Applications of Stochastic Processes (3)
Introduction to stochastic processes, application in queueing theory and inventory theory. Prerequisites: a course in probability theory and IE 317.

443. Automation and Production Systems (3)
Concepts and principles of automated production lines; analysis of transfer lines; partial automation; mechanized assembly system; flexible manufacturing systems; industrial robots; line balancing; product and process design considerations.

444. Design of Cutting Tools (3)
A study of design parameters including tool materials, tool geometry and cutting conditions for material removal operations. Emphasis will be placed on the influence of tool selection variables, on economy of operation and conformance to product requirements.

449. Advanced Computer-Aided Manufacturing (3)
Numerical control in manufacturing; CAD/CAM systems; computer monitoring and control of manufacturing operations; adaptive control of manufacturing operations; adaptive control and other techniques of process optimization. Manufacturing resource planning, computer-aided process planning, and shop floor control. Prerequisite: IE 342 or consent of the department chairperson.

450. Manufacturing Problems (3)
Discussion and solution of manufacturing problems involving several subfunctions, with emphasis on problem identification and definition; selection of techniques of analysis; procedures for evaluation of proposed solutions.

460. Engineering Project (1-6)
An intensive study of an area of industrial engineering with emphasis upon design and application. A written report is required.

461. Readings (1-3)
Intensive study of some area of industrial engineering which is not covered in general courses.

490. Research Methods Seminar (3)
Research methods in industrial engineering; discussion and critiicial analysis of current industrial research; practice in preparation of research proposals.

Interdisciplinary Technology Courses

See listings under Science, Technology and Society.

International Relations

Professors. Carey B. Joynt, Ph.D. (Clark), *Monroe J. Rathbone Professor;* Zdenek J. Slouka, Ph.D. (Columbia), *chairperson;* Oles M. Smolansky, Ph.D. (Columbia), *University Professor.*
Associate professor. Raymond F. Wylie, Ph.D. (London-England).
Assistant professor. M. Rajan Menon, Ph.D. (Illinois).

Curriculum. The program in international relations serves the needs of all types of students. The student concentrating on another field and interested in taking only one or two courses in international relations will find a wide range of selections. Those seeking a more systematic exposure to international relations through a five-course minor program can design their own approach—either to survey the field or to study one of its aspects at a greater depth. For international relations majors, breadth and depth are combined; beyond a solid, common core of courses, the student selects from a range of courses within the international relations field or other disciplines. In this way, an international relations major can study a chosen region in depth (including its languages and culture) or can concentrate on a particular functional field.

To serve these diverse needs, the program of international relations employs concepts drawn from history, political science, economics, philosophy, anthropology, sociology, and psychology, and has strong links with classics, religion studies, and literature. The interdisciplinary design not only fits the tradition of a well-integrated liberal arts education; it also sets the program apart from many other undergraduate curricula which are more tightly anchored in only one or two primary disciplines. The department strongly recommends that all majors in international relations have at least a reading knowledge in one or more foreign languages.

What does the study of international relations encompass, and what is its aim? Scanning the list of courses provides one part of the answer. The aim is a critical understanding of the vast forces shaping the world and penetrating all human activity—nationalism, the dynamics of war and peace, economic diversity, cultural pluralism, ideological drives, and technological change.

Beyond curriculum. The department encourages students to supplement their classroom work with other modes of learning, academic as well as experiential.

In close cooperation with the Center for International Studies, (see page 56), the department assists students interested in internship/study abroad. In addition to summer programs in London, Geneva and Vienna, which combine internships with academic work, eligible students may be placed individually in semester- or year-long internship/study abroad programs in a number of countries.

Every year a variety of outside speakers with diverse international experiences come to the campus and are accessible to students. The department has primary responsibility, together with the Center for International Studies, for managing the Cohen International Lecture Series; the generously endowed series brings to Lehigh community high-ranking leaders and statesmen from around the world.

At a different level, international relations students—majors and non-majors alike—participate in the student-run International Relations Club. The Club's program of activities includes sessions with outside experts, a newsletter, and the preparation for Model UN conferences held at Princeton, Harvard and other institutions. The Club also cooperates with Lehigh's own Upsilon Chapter of Sigma Iota Rho, a national honorary society in international relations. In addition, individual I.R. students are selected every year to represent the University at at various outside events such as the West Point and Naval Academy student conferences.

Beyond college. Apart from serving the fundamental goals of liberal arts education—intellectual development and civic literacy—where does study of international relations lead?

Approximately fifty percent of international relations majors pursue further graduate study in a number of fields—political science, professional schools of international affairs, law, business, and education. Those embarking directly on career paths follow a variety of options—diplomatic service, service in federal and state agencies, careers in international organizations both public and private and including multinational corporations and international banks, or positions in firms engaged in foreign trade.

Major in International Relations

required preliminary courses

IR 2	World Politics: Concepts and Principles (3)

and one of the following:

IR 1	World Politics: Evolution of the International System (3)
IR 11	European International Relations, 1815-1919 (3)
IR 12	European International Relations Since 1919 (3)

required major courses

IR 325	International Political Economy (3) **or**
IR 335	Political Economy of North-South Relations (3)
IR 341	Theories of International Relations (3)
IR 342	The Role of Force in International Relations (3)
IR 361	International Law (3)

and one of the following seminars:

IR 316	Seminar on the Soviet Union and the Third World (3)
IR 326	Seminar in International Political Economy (3)
IR 331	Seminar in International Relations of the Middle East (3)
IR 334	Seminar on Soviet Union in World Affairs (3)
IR 337	Seminar in International Politics of Technology (3)
IR 343	Seminar in U.S. Defense Policy (3)
IR 362	Seminar in International Law (3)

and twelve credit hours, to be selected (with the approval of the major advisor) from courses in international relations, history, government, economics or religion studies.

Departmental Honors
To graduate with honors, a major in international relations must

(a) attain an average of at least 3.5 in the courses constituting the major program;

(b) demonstrate a reading competence in a foreign language; and

(c) complete a 6-credit honors thesis in the senior year.

Minor in International Relations

The minor program is designed for undergraduates of any college who wish to acquire a knowledge of international relations in addition to their major. The program is flexible enough to permit students, in consultation with the minor advisor, to survey the general field of world affairs, or to focus on a specific aspect of it that may relate to their major concentration of study. Students minoring in international relations are required to take five courses (fifteen hours), of which two must be on the senior level.

Undergraduate Courses

1. World Politics: Evolution of the International System (3)
Historical introduction to international politics since 1945. The modern nation-state system; nationalism and imperialism; rise of the super-powers; emergence of the Third World; outlines of a new world order. Menon

2. World Politics: Concepts and Principles (3)
Introductory analysis of major theories of international relations and their application to current problems of world politics. Differing national perceptions on the nature of the international system; the exercise of political, economic and military power in the pursuit of foreign policy objectives; patterns of conflict and cooperation. Menon

10. Model United Nations (1)
Research course leading to the preparation of background materials for Model UN conferences. Hours to be arranged. For pass-fail credit only. Menon

11. European International Relations, 1815-1919 (3)
Politics of the great powers; clashes of interests and international crises; development of alliances and other associations of states; wars and peace settlements; unification of Germany and Italy; influence of nationalism, the industrial revolution, and social ideologies on international relations; World War I and the peace treaties.

12. European International Relations Since 1919 (3)
Political and strategic structure of Europe in the 1920s; rise of Nazi Germany; politics of international crises, 1935-39; World War II and the new distribution of power in Europe; development of the cold war; European functional integration; contemporary European international problems; European relations with the United States.

21. East Asia to 1945 (3)
International relations of East Asia to 1945, with emphasis on 20th century: Western impact and Eastern response; origins and course of Chinese revolution; rise and fall of Japanese empire; emergence of United States and Soviet Union as Asian powers. Wylie

22. Contemporary East Asia (3)
International politics of East Asia since 1945, with emphasis on recent developments: origins of Cold War in East Asia; rise of China as world power; emergence of Japan as industrial giant; policies of United States and Soviet Union in Asia. Wylie

31. Middle East in World Affairs to 1945 (3)
Political, economic, and social forces behind the rise of modern states in the Middle East; area's role in international politics from Napoleon's invasion of Egypt to the end of World War II. Smolansky

32. Middle East in World Affairs Since 1945 (3)
Rise of Turkish, Iranian, and Arab nationalism; creation of Israel; decline of British and French power; growth of U.S. and Soviet influence; Middle East as the world's major oil producer. Smolansky

41. Science, Technology, and International Relations (3)
Interplay between technological change and the international political system. International implications of large-scale, science-based technologies: ocean exploitation system, weather modification, environmental alteration, air space and outer-space technologies, disease controls and agricultural technologies. Slouka

51. American Foreign Policy Since 1945 (3)
Recent and contemporary problems showing how changing international conditions affect the premises, concepts, and objects of U.S. policy. Joynt

80. Politics of Oil (3)
Rise of large international oil companies since 1920 and their relations with the governments of producing and consuming countries, culminating in the formation of the Organization of Petroleum Exporting Countries (OPEC) and the emergence of the 'energy crisis.'

85. Alternative World Futures (3)
Analysis of trends in world politics, global forecasting and alternative futures: global system today; dynamics of change; methods of forecasting; political, economic and social trends; future global scenarios. Wylie

101. Politics of European Integration (3)
Integration process in contemporary West Europe; European communities as examples of peaceful community-building at supranational level. Institutional development of European communities and the political, economic, social dynamics of regional integration in West Europe.

133. Diplomacy of Russia to 1945 (3)
Expansion of the Russian Empire; Russian foreign policy under the tsarist and communist governments; interaction between domestic and foreign affairs; Soviet efforts to survive in a 'hostile capitalist environment.' Smolansky

134. Diplomacy of Russia Since 1945 (3)
Consolidation of gains made during and after World War II; origins of cold war; frictions within the Communist bloc (Eastern Europe and China); nuclear arms race and striving for detente. Smolansky

161. Proseminar in World Politics (3)
Readings on selected themes in world politics, with theme to change each semester. Emphasis on intensive study of texts and development of reading and writing skills through oral and written reports. Prerequisite: consent of department chairperson.

Advanced Undergraduate Courses

302. War and World Politics (3)
The role of war in the modern world; changing functions of war; why nations go to war; great-power wars, limited wars, civil wars, and intervention; the examples of Hitler's Germany, Japan, Korea, Vietman, and the Arab-Israeli conflict. Prerequisites: IR 1 and 2, or consent of the chairperson. Joynt

303. International Peace Studies (3)
The problem of achieving a peaceful world order; the dynamics of conflict; the role of force, law, and morals. Evaluation of the proposed solutions to violent change. The nuclear era and the challenges to order posed by scarce resources and growing interdependence. Prerequisites: IR 1 and 2, or consent of the department chairperson. Joynt

304. Multinational Corporations As International Actors (3)
Economic, political, and social role of multinational corporations in the international system; emphasis on relations between multinational corporations and national governments. Prerequisite: IR 1 or 2.

308. (Govt 308) Ideologies in World Affairs (3)
Theories of ideology; nationalism and imperialism; conservatism/liberalism/socialism; Marxism/Leninism/Maoism; fascism/Nazism/militarism; Third World ideologies; the New Left, the New Right, and other recent trends. Wylie

311. World Affairs, 1919-1945 (3)
International relations between the world wars; structure of the state systems in 1919-22; ideals and realities of the League of Nations; challenge of Nazi Germany, Japan, Fascist Italy, and Soviet Russia; appeasement; crises of the 1930s; and World War II.

312. World Affairs Since 1945 (3)
International relations after World War II; its impact on the state system; cold war and development of bipolar international politics; the United Nations as an instrument for international order and security; decline of the colonial system and emergence of new states; development of Communist China and Western Europe as new power centers; and contemporary problems in international relations.

315. The Soviet Union and the Third World (3)
Political, economic, ideological and military aspects of Soviet policy toward the Third World since 1945. Menon

316. Seminar on the Soviet Union and the Third World (3)
Selected topics on the relations of the Soviet Union and Third World countries. Topic varies each year. Prerequisites: IR 315 and consent of chairperson. Menon

318. (Govt 318) Communist Political Systems (3)
Examination of Communist political systems outside the Soviet Union and the operations of nonruling Communist parties.

321. China in World Affairs (3)
Role of China in world affairs emphasizing triangular relationship involving China, United States, and Soviet Union. Other topics include: Maoist ideology and domestic politics; making of foreign policy; relations with Japan and Europe; policies toward the Third World; current and future problems. Wylie

322. (Govt 322) Politics of Developing Nations (3)
Theories of political development in non-Western areas: modernization and nation building. Field studies and methods; contributions of related disciplines such as sociology and psychology.

323. Japan in World Affairs (3)
Emergence of Japan as key actor in post-1945 world politics. Changes in the international system as well as the internal dynamics of Japan are examined for their contribution to Japan's rise to power. Wylie

325. (Govt 325) International Political Economy (3)
Development of forms of political management of the world economy since World War II, with emphasis on control of interdependence among the industrialized countries, achievement of equity in relations between developed and developing countries, and reintegration of the centrally planned economies into the international economy. Prerequisites: IR 1 and 2, or consent of chairperson.

326. Seminar in International Political Economy (3)
Analysis of selected issues in contemporary international economic relations, with emphasis on O.E.C.D. countries. Topic varies each year. Prerequisites: IR 325 and consent of chairperson.

331. Seminar in International Relations of the Middle East (3)
Importance of the region in contemporary world politics; strategic location and natural resources as factors affecting interests of the great powers. Interplay of international, regional and internal forces. Prerequisites: IR 31 or IR 32 and consent of chairperson. Smolansky

334. Seminar on Soviet Union in World Affairs (3)
Objectives, strategy and tactics of Soviet diplomacy: Russia's status as a superpower. Prerequisites: IR 134 and consent of chairperson. Smolansky

335. Political Economy of North-South Relations (3)
Political economy of relations between developing and developed countries. Political context of foreign aid, trade policy, multinational corporations, and negotiations over the New International Economic Order. Menon

337. Seminar in International Politics of Technology (3)
Research course in selected areas of world politics affected by technological change excluding weapon technologies. Prerequisites: IR 1 or 2, and IR 41 or 335, or consent of chairperson. Slouka

341. Theories of International Relations (3)
Contemporary theories and basic concepts of world politics; application to historic and current issues of international relations. Prerequisites: IR 1 and 2, or consent of the chairperson. Joynt

342. The Role of Force in International Relations (3)
Role of force in international politics: deterrence, limited war, problems of arms control and disarmament; crisis diplomacy. Prerequisites: IR 1 and 2, or consent of the chairperson. Joynt

343. Seminar in U.S. Defense Policy (3)
Analysis of U.S. defense policies. Prerequisites: IR 342 and consent of chairperson. Joynt

353. International Institutions (3)
Role of international institutions in world politics. Interplay and functions of intergovernmental and nongovernmental organizations. Decision making, authority and sources of influence. Political, economic, social and scientific-technological organizations of global and regional scope. Slouka

354. Atlantic Community (3)
Political, cultural, and strategic influences affecting relationship between Western Europe, United States, and Canada; the North Atlantic Treaty Organization; strains in the community, and prospects.

355. Problems in United States Foreign Policy (3)
Analysis of selected major issues in U.S. foreign policy. Prerequisite: IR 51 or consent of chairperson. Joynt

361. International Law (3)
Function of law in international relations, Foundation and structure of international law. Sources of international legal rights and obligations. International law-making and settlement of disputes. Prerequisites: IR 1 and 2, or consent of chairperson. Slouka

362. Seminar in International Law (3)
Case studies in the dynamics of international regulatory processes. Political, socio-economic, and cultural foundations of the international legal system. Prerequisites: IR 361 and consent of chairperson. May be repeated for credit. Slouka

371. Reading in International Relations (3)
Directed course of reading intended for students with special competence or interest in fields of international relations not fully covered by regular course offerings. May be repeated for credit. Prerequisite: consent of chairperson.

372. Reading in International Relations (3)
Continuation of IR 371. May be repeated for credit. Prerequisite: consent of chairperson.

375. Internship in International Relations (1-3)
Internship in public or private agency. May be repeated for credit. Prerequisite: consent of chairperson.

381. Special Topics (3)
Intensive study of some aspects of international politics not covered in another course. Prerequisite: consent of chairperson.

382. Special Topics (3)
Continuation of IR 381. Prerequisite: consent of chairperson.

Journalism

Professor. Sharon M. Friedman, M.A. (Penn State), *chairperson and director of science writing program.*
Associate professor. Walter W. Trimble, M.A. (Ohio State).
Assistant professors. Graham Fysh, M.S. (Columbia), M.A. (Washington); Carole M. Gorney, M.S.J., A.P.R. (Northwestern).

The department of journalism offers major and minor programs in print journalism and science writing as well as a minor program in public relations.

The profession of journalism deals with the truthful communication and explanation of facts. It is the purpose of the program in journalism to bring its majors to a point at which they can gather significant information, organize it quickly and communicate it clearly, accurately and objectively, and to bring them to an understanding of the legitimate role of the mass media in society.

The first of these objectives is attained by extensive, professionally oriented practice in the reporting, writing and editing of the news. Emphasis is placed on precision and clarity of expression and sophistication of style.

The second objective is attained by study of the rights and responsibilities of the mass media under the U.S. Constitution and by a senior seminar course in which problems facing the media and the relationship between the media and society are examined.

The basic program in journalism provides an opportunity for the student to pursue a concentration in at least one of the following areas: American studies, economics, government, history, international relations, languages, literature, philosophy, religion studies, various scientific disciplines, social relations and urban studies. Some journalism students elect to pursue a double major. Others choose a minor or a concentration in one of these fields.

A second major program available to journalism students is science writing. Those selecting this major will learn to write, in terms understandable to the general public, about pure and applied scientific research, technology and engineering, medicine and the environment. A minor in science writing is available for those who wish to major in science or engineering and to become skilled in science communication techniques.

Students interested in environmental writing may wish to pursue a bachelor of science degree in environmental sciences and resource management (ESRM), with a concentration in environmental science writing. This option is offered through the ESRM interdisciplinary program in cooperation with the department of journalism. Students are required to take a core sequence of science courses and eighteen credit hours in the science writing program. For details, refer to the ESRM program description on page 136.

All science and environmental writing students also may enroll in the science writing field research program, which offers a unique opportunity for practical experience in scientific research and science writing. They also may gain experience by serving on the staff of *Science Scope*, a student-written publication devoted to research at Lehigh.

A public relations minor is available to students interested in a career in such areas as nonprofit, governmental and corporate public relations. The courses offered cover theory, skills and practical application of public relations.

Although most journalism graduates choose some phase of written communication as a career—newspapers, wire services, magazines, public relations, advertising, technical writing—others have used their background in journalism as a basis for the study and practice of law, graduate study in a variety of disciplines, government service, teaching and business management.

Those concentrating in science writing can expect to pursue careers in science journalism; in public information or public relations for scientific societies, government agencies, universities or hospitals; in technical writing; and in other areas, such as management, administration and teaching, in which science communication skills are highly desirable. The program also prepares students for graduate study in science writing, journalism and other disciplines.

Basic Journalism Major

required preliminary courses

Jour 1, 2	Brown & White (2)
Jour 11	News Writing (4)

required major courses

Jour 3-8	Brown & White (2-6)
Jour 113	Editing (3)

Jour 114	Reporting of Public Affairs (4)
Jour 117	Magazine Article Writing (3)
Jour 122	Law of the Press II (3)
Jour 315	Interpretive Writing (3)
Jour 320	Journalism Proseminar (3)
Govt 77	Urban Politics (3)

Note: *Brown* and *White* must be rostered each semester while the student is a journalism major, and a minimum of four such semesters is required. The course involves work on the student newspaper. With the approval of the journalism faculty, current professional newspaper or other media experience may be substituted semester by semester.

Dual major and recommended electives. Journalism majors are encouraged to declare dual majors in journalism and another field, such as one of those discussed under concentrations above. In-depth knowledge of a specialty area is considered an asset to a journalism career. Those not desiring to declare a dual major should consider either declaring a minor in one of these fields or concentrating their elective courses in one or two of these areas. Dual majors, minors and concentration areas should be chosen in consultation with the major adviser.

Journalism/Science Writing Major

Jour 1-8	Brown & White (1-8)
Jour 11	News Writing (4) **or**
Jour 123	Basic Science and Technical Writing (3)
Jour 113	Editing (3)
Jour 114	Reporting of Public Affairs (4)
Jour 122	Law of the Press II (3)
Jour 124	Politics of Science (3)
Jour 125	Environment, the Public and the Mass Media (3)
Jour 128	Writing for Public Relations (3)
Jour 313	Special Topics in Science Writing (3)
Govt 77	Urban Politics (3)

Note: Those concentrating in science writing must roster *Brown and White,* each semester after declaring the major. A minimum of four such semesters is required. Current professional newspaper or other media experience may be substituted semester by semester.

Required science courses. A minimum of twenty-four credits in the physical, biological, environmental or social sciences or engineering is required. These hours can be concentrated in any one area or distributed among all five areas, although an area concentration is recommended. Dual majors in journalism/science writing and a science are encouraged. Science courses should be chosen in consultation with the major adviser.

Science writing field research program. Available to science or environmental writing students at the junior or senior level, this program provides practical experience in scientific research and science writing for students who work on and write about research projects directed by university scientists and engineers.

Another segment of the program allows students to attend major scientific meetings as fully accredited science reporters. Students observe professional science writers in action and write their own stories about the scientific sessions and press conferences held at the meetings.

Journalism Minor

Students who wish to declare a minor program in journalism must be majors in another discipline and take the following:

Jour 1-3	Brown & White (3)
Jour 11	News Writing (4)
Jour 113	Editing (3)
Jour 122	Law of the Press II (3)
Jour 315	Interpretive Writing (3)

Sixteen credits are required.

Science Writing Minor

Students desiring to minor in science writing must be majors in another discipline, preferably a science or engineering. The following courses are required:

Jour 1-2	Brown & White (2)
Jour 11	News Writing (4) **or**
Jour 123	Basic Science and Technical Writing (3)
Jour 124	Politics of Science (3)
Jour 125	Environment, the Public and the Mass Media (3)
Jour 128	Writing for Public Relations (3)
Jour 312	Advanced Science Writing (3) **or**
Jour 313	Special Topics in Science Writing (3)

Seventeen credits are required.

Public Relations Minor

Students minoring in public relations must be majors in another discipline and take the following courses:

Jour 11	News Writing (4)
Jour 30	Feature Writing (3) **or**
Jour 117	Magazine Article Writing (3)
Jour 127	Public Relations Theory (3) **or**
Jour 306	Applied Public Relations (3)
Jour 128	Writing for Public Relations (3)
Jour 161	Internship (3)
Jour 229	Public Relations Case Studies (3)

Nineteen credits are required.

Journalism Courses

Media Internships
With the approval of the journalism faculty, qualified students may acquire professional experience with area newspapers and magazines or in institutional and agency advertising and public relations. (See Jour 161.)

1. Brown and White (1) every semester
Enrollment constitutes membership on the staff of the semi-weekly undergraduate newspaper.
Jour-2-10 Brown and White (1-2).

11. News Writing (4) every semester
Definition, determinants, and components of news; news story structure and style; sources; interviewing; practice in gathering and writing news.

30. Feature Writing (3) spring
Defining and developing feature stories: human interest, historical, color, personality and news issues; specialized interviewing and writing techniques. Prerequisite: Jour 11 or Jour 123 or consent of department chairperson. Trimble

113. Editing (3) every semester
Study of and practice in newspaper desk work; headline writing, makeup, and typography; selecting, editing and rewriting news and feature copy; use of reference works and newspaper libraries. Prerequisite: Jour 11 or Jour 123. Trimble, Fysh

114. Reporting of Public Affairs (4) spring
Reporting and writing news of government on the local, county, state and federal levels; civil and criminal courts; labor, environment, housing and community planning news. Prerequisites: Jour 11 or Jour 123 and Govt 77. Trimble

117. Magazine Article Writing (3) fall
Writing and marketing nonfiction magazine articles. Prerequisite: Jour 11 or Jour 30 or Jour 123. Gorney, Fysh

118. History of American Journalism (3)
English background of the American newspaper; development of press from colonial days to the present; influence of

newspapers on American life; contributions of outstanding journalists.

121. Law of the Press (3)
Constitutional development of freedom of the press; rights and responsibilities of the press. Zirkel

122. Law of the Press II (3) spring
Law of and defenses in libel; privacy; contempt; copyright; obscenity. Prerequisite: Jour 11 or Jour 123 or Law 11. Zirkel

123. Basic Science and Technical Writing (3) fall
Writing about science and technology subjects for audiences ranging from lay persons to scientists and engineers. Includes instruction in news and feature writing plus interviewing for lay audiences, with emphasis on organization and clear writing techniques. As course progresses, material becomes more technical in nature, concentrating on how to write effective technical reports and scientific journal articles. Prerequisite: six hours of science or consent of department chairperson. Friedman

124. (STS 124) Politics of Science (3) spring
Organization of the U.S. scientific community and how it interacts with government, the mass media and the public. Friedman

125. Environment, the Public and the Mass Media (3) fall
Public perceptions of environmental problems and of roles played by business, government, the mass media and environmental groups. Analysis of techniques of persuasion, with student investigations of regional environmental problems. Friedman

127. Public Relations Theory (3)
Emphasis on management function of public relations, including research, planning, programming, communications and evaluation. Study of communication and persuasion theory, public opinion, crisis management and ethics. Student teams apply theory to practical organizational problems. Gorney

128. Writing for Public Relations (3) spring
Study of the preparation and writing of publicity for print and broadcast media, publications (newsletters, pamphlets, annual reports), speeches and audio-visual presentations, especially for non-profit and environmental groups. Prerequisite: Jour 11 or 123 or 311 or consent of department chairperson. Friedman, Gorney

131. Science Writing Practicum (1-3)
On-site experience as accredited science reporter at major scientific meetings, or writing and research in university laboratories as part of Science Writing Field Research Program. May be repeated for a maximum of eight credits. Prerequisites: Jour 11 or Jour 123 or Jour 311, junior standing, and consent of the department chairperson. Friedman

141. Photojournalism (3)
Ethics and history of photojournalism; practice in techniques of distinguished photojournalists, camera use and darkroom. Students must provide own 35mm. camera. Enrollment limited. Prerequisite: consent of department chairperson. Trimble, Gorney

161. Internship (3) every semester
Professionally supervised work on commercial newspapers, magazines, radio and television stations, or with public relations and advertising organizations. Some internships involve science writing. May be repeated for a maximum of six credits. Prerequisite: consent of department chairperson. Friedman

211. Problems in Advanced Reporting (3)
Intensive practice in the reporting of complex events. Prerequisite: Jour 114. Fysh

212. Problems in Advanced Reporting (3)
Techniques of investigative reporting. Prerequisite: Jour 114. Fysh

229. Public Relations Case Studies (3) fall
Analysis of public relations programs in business, industry, government, and non-profit organizations. Emphasis on specific problems and methods used. Prerequisite: Jour 127 or consent of department chairperson. Gorney

306. Applied Public Relations (3) spring
Application of public relations theories and practices to hypothetical and real problems in business, government and non-profit organizations. Prerequisites: Jour 127 and Jour 128 or consent of department chairman. Gorney

311. Science and Technical Writing (3) fall
Study of and practice in writing about science and technology for general print, electronic media and specialized science publications. Includes news and feature articles, report writing and analysis of factors that influence science communication to the public. Emphasis on writing and organizational skills and translation of scientific materials into lay language. Should be taken by upperclass and graduate students instead of Jour 123. Prerequisite: six hours of science or consent of department chairperson. Friedman

312. Advanced Science Writing (3)
Further practice, on individual basis, in science writing techniques. Prerequisite: Jour 123 or 311. Friedman

313. Special Topics in Science Writing (3) fall
Interpretive writing on controversial or complex scientific and technological topics. Emphasis on in-depth investigations, interviewing and balanced reporting. Prerequisite: Jour 11, or Jour 123, or Jour 311, or consent of the department chairperson. Friedman

315. Interpretive Writing (3) every semester
Editorial interpretation of current events; practice in interpretive reporting and editorial writing. Prerequisite: Jour 11. Fysh

320. Journalism Proseminar (3) spring
Survey of the press in its relation to public affairs. Extensive research and reports. Prerequisite: consent of the department chairperson. Trimble and staff

Languages

See course descriptions listed alphabetically under Modern Foreign Languages.

Latin American Studies

See listings under Modern Foreign Languages. See also Foreign Careers, where an undergraduate may concentrate on Latin America as a geographical concentration.

Law and Business

Professors. Brian G. Brockway, J.D., LL.M. (Georgetown), *Distinguished Professor of Law, chairman;* Perry A. Zirkel, J.D., Ph.D. (Connecticut), *University Professor of Education and Law.*
Assistant Professors. Ifeanyi Achebe, J.D., LL.M. (New York University); George Nation III, J.D. (Villanova).

The Department of Law and Business is responsible for the law program in the College of Business and Economics and participates in the Law and Legal Institutions program.

Members of the Department provide pre-law advice for students in the College. A major program of studies is not offered.

Undergraduate Courses

11. Introduction to Law (3)
A study of the nature and function of law and the legal system, the study of legal reasoning through the use of the case method. Required first course in the Law and Legal Institutions minor program. Open only to freshmen and sophomores except with the consent of the coordinator of the program.

201. Legal Environment of Business (3) Every semester.
The study of the legal relationships of business and government, business and society and the individual and society. The case method is used to develop analytical skills. Introduction to contract law underlying the free market system. Prerequisite: Eco 1.

202. Business Law (3) fall
The law of sales, contracts, agency, business organizations, secured transaction, property and negotiable instruments. Prerequisite: Law 201.

221. (Phil 221) Sex-Discrimination and the Law (3)
A critical study of the law of sex discrimination in areas of constitutional and labor law. A case approach that places emphasis on the rights of employees and the obligations of employers. Topics include equal protection, equal employment opportunity, and affirmative action. Lindgren

371. Directed Readings (1-3)
Readings in various fields of law, designed for students who have a special interest in a field of law.

372. Special Topics (3)
Special problems and issues in commercial law.

Graduate Courses

404. Legal Environment of Management (3)
The effect of public and private law on business decisions. The legal relationship of business and society and business and government, especially the government regulation of business. Introduction to contract law underlying the free market system.

432. Legal Problems in Business (3)
Specific legal problems involved in making business decisions. Emphasis is placed on preventive law and the tax consequences of business transactions. Prerequisite: a course in law and corporation finance.

437. Federal Taxation and Business Decisions (3)
Impact of federal taxation on the structure and timing of business decisions. Problem-solving methods and research techniques from a managerial perspective. Not available to students with two or more courses in taxation. Prerequisite: a basic course in accounting.

Management

Professors. Richard W. Barsness, Ph.D. (Minnesota), *dean of the College of Business and Economics;* Alden S. Bean, Ph.D. (Northwestern), *Kenan Professor of Management and Technology;* John W. Bonge, Ph.D. (Northwestern); James B. Hobbs, D.B.A. (Indiana), *Frank L. Magee Professor of Business Administration, and director MBA program;* Benjamin Litt, Ph.D. (N.Y.U.).
Associate professors. Michael G. Kolchin, D.B.A. (Indiana); John E. Stevens, Ph.D. (Cincinnati), *chairman.*
Instructor. John F. Bunch, B.A. (Michigan).

Management Program and Courses

Each undergraduate management major will select either the *Specialization* (15 hours) or *Interfunctional* (18 hours) track shown below:

Specialization (15 hours)

required courses:

Mgt 302	Quantitative Model-Conceptual (3)
Mgt 321	Organizational Behavior Workshop (3)

*Plus at least one of the following:

Mgt 309	Industrial Purchasing and Materials Management (3)
Mgt 311	LUMAC Management Assistance Counseling (3)
Mgt 331	Industrial Relations and Public Policy (3)
Mgt 333	Personnel Management (3)

Up to two of the following:

Acct 324	Cost Accounting (3)
Eco 333	Managerial Economics (3)
Eco 335	Labor Economics (3)
Eco 352	Advanced Statistical Methods (3)
Eco 357	Econometrics (3)
Fin 328	Corporate Financial Policy (3)
Mkt 319	New Product Planning (3)
Mkt 321	Marketing in the Industrial Environment (3)
IE 309	Introduction to Information Systems (3)
IE 311	Decision Processes (3)
IE 325	Production Control (3)

*Courses other than Mgt 302 and Mgt 321 will be selected in consultation with the faculty advisor to comprise one of currently five specialization options.

Interfunctional (18 hours)

required courses:

Mgt 302	Quantitative Model-Conceptual (3)
Mgt 321	Organizational Behavior Workshop (3)
Acct 324	Cost Accounting (3)
Fin 328	Corporate Financial Policy (3)
Mkt 319 or Mkt 321	New Product Planning (3) or Marketing in the Industrial Environment (3)

Plus one of the following:

IE 309	Introduction to Information Systems (3)
IE 311	Decision Processes (3)
IE 325	Production Control (3)

Undergraduate Courses

Mgt 1. Introduction to Business Computing (3) fall and spring
A one-semester survey of computer technology and software applications in business and economics. Topics include introduction to computer architecture and logic, operating systems, spreadsheets, and data base management systems. Students will develop a working knowledge of microcomputers, mainframes and the campus-wide network. Limited to freshmen only. (Mgt. 1 will be a prerequisite for many courses in the College of Business and Economics.)

Mgt 101. (ECO 101) Introduction to Quantitative Methods (3)
Mathematical concepts within a business and economics framework: linear algebra, partial derivatives, constrained optimization, and integral calculus. Meets mathematics prerequisite for entering students in the master of business administration program. Not available for credit to undergraduates in the College of Business and Economics.

Mgt 269. Management of Operations in Organizations (3) fall-spring
Design, operation and control of activities necessary to generate goods or services of profit and nonprofit

organizations. Basic concepts and quantitative modes used in operations. Eco 145, Math 44. Stevens

Mgt 270. Organization Theory and Behavior (3) fall-spring
Formal organizations as ongoing systems. Emphasis is placed on the introduction of theory applicable to the management of human behavior in work environments. Issues at the individual, group, and organizational levels of analysis are addressed. Topics covered include motivation, stress, career processes, leadership, conflict management, decision making, work politics, organizational design, and organizational development. Kolchin, Bunch

Mgt 301. Business Management Policies (3) fall-spring
Case study of business problems and the formulation of policies, strategies and tactics to resolve those problems from the viewpoint of general management. Long-range goal attainment, policy formulation, and administrative implementation for specific functional areas and the total firm. Prerequisite: senior standing in the College of Business and Economics, and completion of the college core.

Mgt 302. Quantitative Model-Conceptual (3)
Quantitative methodologies and their use in business, economics and related areas. Classical optimization techniques, mathematical programming, linear programming, decision theory, game theory, simulation and network models. Prerequisites: Eco 105, Acct 111 and Mgt 269.

Mgt 306. Entrepreneurship and Business Policy (3) spring
Case study of problems in creating new ventures or managing family-owned businesses. Integrates knowledge acquired in other courses and stresses development of strategic and administrative policies for particular functions and the company as a whole. Prerequisites: senior standing, completion of College of Business and Economics core, and Mgt 311, as well as approval of the department chairperson. Students may not receive credit for both Mgt 306 and Mgt 301. Bonge

Mgt 307. Business Communication Skills (3)
Written and spoken communication through letters, memos, reports, and oral presentations. Formal and informal communication networks, and communication processes. Prerequisite: consent of instructor. West

Mgt 309. Industrial Purchasing and Materials Management (3) spring
Negotiating, purchasing, receiving, storing, inventory control, value analysis, procurement information systems, and specialized problems in institutional and government procurement. Lectures and cases. Prerequisite: Mgt 269 or equivalent. Kolchin

Mgt 311. LUMAC Management Assistance Counseling (3) fall-spring
A field studies course providing management assistance to small businesses in the Lehigh Valley. Students work in small groups under faculty supervision on a direct basis with owners. Problem solving and experience in applying marketing, accounting, finance, and/or management concepts to business. Prerequisites: junior standing in the College of Business and Economics. Bonge, Stevens

Mgt 321. Organizational Behavior Workshop (3)
A workshop course examining individual behavior, interpersonal transactions and behavioral processes in small work groups through motivational analysis, role-playing nonverbal interactions, problem solving and group simulations. Prerequisites: Mgt 270 and permission of the department chairperson. Kolchin, Bunch

Mgt 331. Industrial Relations and Public Policy (3)
An examination of the evolution and current status of U.S. public policy toward the organization and recognition of labor unions, collective bargaining, labor contract administration, and arbitration of disputes as expressed in federal statutes, court decisions, and National Labor Relations Board rulings. Stevens

Mgt 333. Personnel Management (3) fall
Analysis and resolution of personnel problems in organizations. Human resource planning, recruitment, selection, orientation, training, appraisal, compensation, and development. Lectures and cases. Prerequisite: Mgt 270. Kolchin, Stevens

Mgt 371. Directed Readings (1-3)
Readings in various fields of management designed for the student who has a special interest in some field of management not covered by the regularly scheduled courses. Prerequisite: consent of the department chairperson. May be repeated.

Mgt 372. Special Topics (1-3)
Special problems and issues in management for which no regularly scheduled coursework exists. When offered as group study, coverage varies according to interests of instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

For Graduate Students

Mgt 401. Quantitative Methods in Business and Economics (3)
Quantitative methodologies and applications. Classical optimization techniques, mathematical programming, simulation, decision theory, game theory, network models and statistics. Prerequisite: Eco 401.

Mgt 409. Purchasing and Materials Management (3)
Overview of the purchasing and materials functions in organizations: Negotiation, buying, receiving, storing, inventory control, value analysis, legal aspects, and specialized problems in institutional and government procurement. Combination of lectures and case analyses. Kolchin

Mgt 413. Organizational Behavior (3)
Interpersonal and group behavior in organizations. Issues of organizational work and perception, motivation, communications conflict dynamics, intergroup relations, and leadership. Kolchin, Litt

Mgt 423. Operations Management (3) spring
The operations function from the perspective of general management. Development of operations policy in the context of the firm's over-all strategy. Prerequisites: Eco 401 and Mgt 401.

Mgt 425. Human Resource Management (3)
A survey of personnel management activities in organizations. Topics include human resource planning, recruitment, selection, equal employment opportunity, evaluation, compensation, career planning, safety and health. Kolchin, Stevens

Mgt 429. Managerial Policy and Decision-Making (3) fall-spring
Integration of theory and analytic techniques through intensive investigation of complex organizational, strategic and financial problems in industrial and nonbusiness entities. Case studies. Prerequisite: graduate-level exposure to accounting, economics, finance, management and marketing. An MBA candidate should take the course near the end of the MBA program. Hobbs, Kolchin

Mgt 430. (IE 430) Management Science Project (3)
As an individual or as a member of a small group, analysis of a management problem and the design of its solution is made incorporating management science techniques. An individual written report is required. Recommended that it be taken in the last semester of the M.S. in management science program.

Mgt 431. Organizational Design and Change (3) fall
Variables relevant to determining the design of structures and processes of organizations; techniques pertinent to organizational adaptation to changed environments, technologies and social factors. Prerequisite: Mgt 413. Bonge

Mgt 433. Corporate Enterprise: Concepts and Issues (3)
Examines issues relevant to modern corporate enterprises: managing technological innovation; role of public policy; managerial values-ethics and human resources. Bean, Litt

Mgt 435. Organizational Decision Processes (3)
Examines individual responsibility and information handling styles in managerial decision-making processes in formal organizations. Negotiated decision-making, joint problem solving, and values based decision-making processes. Prerequisite: Mgt 413. Litt

Mgt 445. (IE 445) Advanced Mathematical Programming (3)
Theory and applications of the extensions of linear programming. Tucker-Kuhn conditions, gradient methods of optimization, simplex-based methods of nonlinear programming, integer programming, branch and bound, zero-one discrete programming and stochastic programming. Prerequisite: a course in linear programming.

Mgt 447. Analytical Methods in Management (3)
Application of management science methods to industrial and commercial problems. Scientific method, decision theory, linear programming, inventory control, regression analysis, forecasting, simulation, and related areas are examined in the context of accounting, finance, marketing, and manufacturing.

Mgt 455. Managerial Communication Skills (3)
Organization, style, and strategy of language to inform, direct, and persuade. Application of writing, reading, speaking, and listening skills to managerial problems. Case studies. West

Mgt 471. Directed Readings (1-3)
Graduate readings in management not covered in regularly scheduled coursework. Prerequisite: consent of the department chairperson. May be repeated.

Mgt 472. Special Topics (1-3)
Special problems and issues in management for which no regularly scheduled graduate coursework exists. When offered as group study, coverage will vary according to the interests of instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

Manufacturing Systems Engineering

Program director. Roger N. Nagel, Ph.D. (Maryland), *professor of computer science and electrical engineering.*
Program faculty. Mikell P. Groover, Ph.D. (Lehigh), *professor of industrial engineering;* Benjaminn Litt, Ph.D. (N.Y.U.), *professor of management;* John B. Ochs, Ph.D. (Penn State), *associate professor of mechanical engineering and mechanics;* Nicholas G. Odrey, Ph.D. (Penn State), *associate professor of industrial engineering;* N. Duke Perreira, Ph.D. (California, Los Angeles), *associate professor of mechanical engineering and manufacturing systems engineering;* Richard Roberts, Ph.D. (Lehigh), *professor of mechanical engineering and mechanics;* Bruce M. Smackey, Ph.D. (Rensselaer), *associate professor of management and marketing;* Emory W. Zimmers, Jr., Ph.D. (Lehigh), *professor of industrial engineering;* Tulga Ozsoy, Ph.D. (Tech. Univ. of Istanbul), *assistant professor of mechanical engineering and mechanics;* George R. Wilson, Ph.D. (Penn State), *associate professor of industrial engineering.*

The graduate curriculum in MSE is designed to develop engineers who can design, install, operate and change manufacturing systems which involve people, machines, new materials, information systems and appropriate technology. It is a program which integrates systems perspectives with interdisciplinary education and training.

This curriculum leads to a Master of Science degree in Manufacturing Systems Engineering and is designed as a one-year full-time program starting each January. It requires a minimum of 30 credits, and includes weekly seminars and summer plant tours and projects.

Graduate Courses

421. Managing the Corporate Manufacturing Function (3)
The corporate manufacturing activity as an integrated social-technical-economic system from the executive and middle management viewpoints. Examines financial and behavorial implications of manufacturing systems decisions such as: capacity and plant location; labor relations; make or buy decisions; and start up/shut down operations.

423. Product Design/Analysis (3)
The integrated approach to the product design process using computer-aided design (CAD) systems. Wire-frame and solid modeling, finite element methods, kinematic analysis and synthesis, and other computer-assisted techniques applied to mechanical and electrical/electronics design. The importance of manufacturability is stressed.

425. Production Planning and Resource Allocation (3)
Capacity planning, scheduling, inventory control, and other topics in the management of manufacturing resources. Discrete and continuous simulation models for analysis and design of production systems. Factory information systems and data bases for computer integrated manufacturing.

427. Production Systems (3)
Modern production and assembly methods used in the mechanical and electrical/electronics industries. Techniques for deciding the most appropriate production method for a new product. Computer-aided process planning, group technology, robotics, numerical control, and other automated manufacturing methods.

431. Management, Technology and Business Enterprise (3)
Strategy and policy level issues for managing technology forecasting and business enterprise. Topics include marketing and product strategies, managing organizational entrepreneurship, managing R/D and continuing technological change.

433. Technology and the Factory of the Future (3)
Engineering and technological issues that will affect future developments in manufacturing. Topics include flexible automation systems, integration of design and production through CAD/CAM, the factory data network, smart sensors, intelligent machines, the man-machine interface, and the manufacturing management information system.

451. Manufacturing Systems Engineering Project (3)
Eight-week project work involving the solution of a problem in manufacturing systems engineering. A written report is required.

490. Manufacturing Systems Engineering Thesis (6)
Students will conduct MSE thesis research beginning in the summer. Students will continue their thesis research in the fall semester.

Marketing

Professor. Raymond L. Horton, D.B.A. (Indiana), *chairman.*
Associate professors. James E. Hansz, Ph.D. (Cincinnati); Bruce M. Smackey, Ph.D. (Rensselaer).
Assistant professor. James M. Maskulka, D.B.A. (Kent State).
Instructor. Therese A. Maskulka, M.B.A. (Gannon).

The marketing major in the College of Business and Economics consists of fifteen credit hours from the following courses:

Required courses

Mkt 312	Marketing Research (3)
Mkt 313	Marketing Communications (3)

Elective courses

Three courses (nine credit hours) from the following:

Mkt 315	Consumer Behavior (3)
Mkt 316	Advertising (3)
Mkt 319	New Product Planning (3)
Mkt 320	International Marketing (3)
Mkt 321	Marketing in the Industrial Environment (3)
Mkt 371	Directed Readings (1-3)
Mkt 372	Special Topics (1-3)

Other approved courses may be used as marketing electives depending upon student's career orientation.

For Advanced Undergraduates and Graduate Students

Mkt 211. Contemporary Marketing (3) fall-spring
The course examines contemporary marketing from a managerial perspective. Design of marketing programs within the context of consumer behavior, the social, economic, and cultural environment, market segmentation, demand, and industry structure. Prerequisite: Eco 105.

Mkt 312. Marketing Research (3) fall-spring
Quantitative and qualitative information in routine and nonrecurring decision-making. Statistical design of marketing studies, model building, analysis of research studies, and the development of marketing information systems. Case problems and presentation of student research projects examine problems in communicating research results. Prerequisites: Eco 145 and Mkt 211. Hansz, Horton, Smackey

Mkt 313. Marketing Communications (3) fall-spring
Communication-promotion decision processes of organizations. Impact of source, message and media variables on audience response to communication campaigns and the interactions among these variables. Role of personal selling, sales promotion, publicity, and advertising in marketing. Prerequisite: Mkt 211. Horton, T. Maskulka

Mkt 315. Consumer Behavior (3) fall-spring
Principal theories of psychology, social psychology, anthropology and economics which contribute to understanding the behavior and motivations of consumers. Consumer needs and wants; learning theory; the perceptual process; decision-making processes; communication; search behavior; market segmentation and product differentiation; and the adoption and diffusion of innovations. Prerequisite: Mkt 211 and Mkt 312. Horton

Mkt 316. Advertising (3) fall-spring
Analysis of advertising campaigns and the societal implications of advertising are considered from a managerial perspective. Prerequisite: Mkt 313. J. Maskulka

Mkt 319. New Product Planning (3) spring
Organization and management of marketing activities related to the development of new and improved products and services. The role of marketing research and product testing in the commercialization process. Application of risk analysis to the screening of ideas for new product candidates. Prerequisites: Mkt 211 and Fin 225. Smackey

Mkt 320. International Marketing (3) spring
The foreign market entry strategies firms may use are examined: export, contractual arrangements, and investment. Student companies implement each strategy on a multinational business game. Prerequisites: Fin 225 and Mkt 211. Hansz, J. Maskulka

Mkt 321. Marketing in the Industrial Environment (3) fall
Strategies and problems in marketing industrial products and services. Role of a direct sales force and development of consultative sales approach in industrial marketing. Prerequisites: Fin 225 and Mkt 211. Smackey

Mkt 330. Retail Management (3) fall
Full coverage of all major retailing topics including consumer behavior, marketing research, store location, service retailing, the retail audit, retail institutions, and international retailing. Students work in groups to conceptualize and develop a retail store of their choice. Prerequisites: Mkt 211 and Mkt 312. T. Maskulka

Mkt 371. Directed Readings (1-3)
Readings in various fields of marketing designed for the student who has a special interest in some field of marketing not covered in regularly scheduled courses. Prerequisite: consent of the department chairperson. May be repeated.

Mkt 372. Special Topics (1-3)
Special problems and issues in marketing for which no regulary scheduled coursework exists. When offered as group study, coverage will vary according to the interests of the instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

For Graduate Students

Mkt 411. Marketing and the Multinational Firm (3)
Stages in the development of multinational firms are developed from initial use of marketing intermediaries, through the evolution of overseas production and marketing, to the eventual integration of the multinational firm. Student companies progress through each stage utilizing the medium of computer simulation. Prerequisites: Fin 411 and Mkt 413. Hansz, J. Maskulka

Mkt 413. Marketing Management (3) fall-spring
Planning and managing marketing activities: market analysis, buyer behavior, market segmentation, marketing research, product policy and strategy, distribution channels policy, advertising, and sales force management. Prerequisite: Eco 405.

Mkt 433. Strategic Marketing (3) spring
The roles of customer functions served, customer groups served, and technologies utilized in defining their business are considered. Students perform a marketing audit and develop a marketing plan. Prerequisite: Mkt 413. Hansz, J. Maskulka, T. Maskulka

Mkt 435. Marketing Information and Decision-Making (3) fall
Obtaining relevant marketing information for decision-making is examined from two perspectives: special projects and information systems. Student projects. Prerequisite: Mkt 413. Hansz

Mkt 437. Advertisting Management (3) fall
Analysis of consumer and industrial advertising campaigns from a managerial perspective. Prerequisite: Mkt 413.

Mkt 439. Industrial Marketing and Sales Management (3) fall
Marketing and sales problems associated with manufacturers of industrial products: organization and productivity of the sales force, product line policies, pricing strategies, buyer requirements, customer service, and formal proposals. Prerequisites: Fin 411 and Mkt 413. Smackey

Mkt 441. Technological Innovation in Organizations (3) spring
Analysis of problems associated with developing and marketing new products and processes in technologically oriented enterprises, from inception of idea to planning marketing strategies. Prerequisites: Fin 411 and Mkt 413. Smackey

Mkt 443. Buyer Behavior and Marketing Management (3) spring
Concepts, methodologies, and current research involving consumer and organizational buying behavior. Prerequisite: Mkt 413. Horton

Mkt 445. Management of Sales Operations (3) fall
Planning and organizing strategic sales programs; developing the sales force through recruitment, training, and motivation; control of sales programs through performance evaluation of sales personnel; and integrating sales with other marketing activities. Prerequisite: Mkt 413.

Mkt 462. Research Methodology (3) spring, odd-numbered
Criteria which distinguish scientific research from other significant human activities; development of concepts, laws and theories; general principles of research design; measurement theory; and scientific values and ethics. Students are expected to prepare a defensible dissertation proposal during the course. Open only to doctoral students. Horton

Mkt 463. Advanced Data Analysis (3) spring, even-numbered years
Applications oriented analysis of variance, regression analysis, and multi-variate analysis. SPSS, BMD, and other computer packages are used to analyze empirical data. Prerequisite: Intermediate statistics or permission of department chairperson. Horton

Mkt 471. Directed Readings (1-3)
Graduate reading in marketing not covered in regularly scheduled courses. When offered as group study, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the chairperson. May be repeated.

Mkt 472. Special Topics (1-3)
Problems and issues in marketing for which no regularly scheduled graduate coursework exists. When offered as group study, coverage varies according to the interests of the instructor and students. Prerequisite: consent of the department chairperson. May be repeated.

Materials Science and Engineering

Professors. David A. Thomas, Sc.D. (M.I.T.), *chairperson;* Betzalel Avitzur, Ph.D. (Michigan), *director of Institute for Metal Forming;* Sidney R. Butler, Ph.D. (Penn State); Ye T. Chou, Ph.D. (Carnegie-Mellon); Joseph I. Goldstein, Sc.D. (M.I.T.), *Vice President for Research;* Walter C. Hahn, Jr., Ph.D. (Penn State); Richard W. Hertzberg, Ph.D. (Lehigh), *New Jersey Zinc Professor;* Ralph J. Jaccodine, Ph.D. (Notre Dame), *Sherman Fairchild Professor;* R. Wayne Kraft, Ph.D. (Michigan); John A. Manson, Ph.D. (McMaster, Ontario); Michael R. Notis, Ph.D. (Lehigh); Alan W. Pense, Ph.D. (Lehigh), *R. D. Stout Professor;* Donald M. Smyth, Ph.D. (M.I.T.), *director of Materials Research Center;* S. Kenneth Tarby, Ph.D. (Carnegie-Mellon); David B. Williams, Ph.D. (Cambridge); John D. Wood, Ph.D. (Lehigh).
Associate professors. Martin P. Harmer, Ph.D. (Leeds, England); Charles E. Lyman, Ph.D. (M.I.T.).
Assistant professors. Helen M. Chan, Ph.D. (Imperial College of Science and Technology, England); Himanshu Jain, Engr.Sci.D. (Columbia).
Adjunct professors. Arnold R. Marder, Ph.D. (Lehigh); Gary A. Miller, Sc.D. (M.I.T.); James P. Snyder, Ph.D. (Lehigh); Seymour Traub, J.D. (Georgetown); Chester J. Van Tyne, Ph.D. (Lehigh).
Professors emeriti. George P. Conrad II, Sc.D. (M.I.T.); Joseph F. Libsch, Sc.D. (M.I.T.); Robert D. Stout, Ph.D. (Lehigh).
Research engineers and scientists. Guy M. Connelly, M.S. (Lehigh); Dang-Rong Liu, Ph.D. (Cambridge); Bruce R. Somers, Ph.D. (Lehigh).

As science and technology advance in the 1980s and beyond, progress in many fields will depend on the discovery and development of new materials, processed in more complex ways, and with new kinds of properties. It is widely recognized that the progress of history has been divided into periods characterized by the materials that mankind has used, i.e., the stone age, the bronze age, the iron age. Today, materials science and engineering is critical to all other fields of engineering, and advances in these other fields are often limited by advances in materials.

Interest in new materials for solid-state devices and space technology, as well as a better understanding of the behavior of materials in the design of structures, automobiles and aircraft, plant processing equipment, electrical machinery, etc., have increased the need for people trained in science and technology of materials.

Education for this field of engineering requires basic studies in mathematics, chemistry, physics and mechanics, plus a general background in engineering principles, followed by intensive training in the application of scientific and engineering principles to the development and use of materials in a technological society. In addition, the curriculum offers an introduction to humanistic and social studies; these broaden the student's outlook and enhance professional development after graduation.

The undergraduate program is designed to train graduates for research, development, operations, management and sales careers in industry or for graduate study in various specialties of the field, including the manufacture and applications of metals, ceramics, polymers, composites, and electronic materials. While some graduates go directly into materials-producing companies, a large proportion serve as engineers in the chemical, electrical, transportation, communications, space and other materials consumer industries. A number of students pursue graduate study leading to careers in research and teaching.

Major Requirements

The recommended sequence of courses is shown. The standard freshman engineering year is shown on page 36.

sophomore year, first semester (17 credits)*

Math 23	Analytic Geometry and Calculus III (4)
Phys 21, 22	Introductory Physics II and Laboratory (5)
Eco 1	Economics (4)
Mat 63	Engineering Materials and Processes (3) **or**
Mat 93	Introduction to Solid State Materials (3) or General Studies elective (3)
Mat 10	Materials Laboratory (1)

*Mat 10 and Mat 63 or 93 are required and should normally be taken during the sophomore year. However, they may be taken in the first semester of the junior year.

sophomore year, second semester (15-16 credits)

Math 205	Linear Methods (3) **or**
Math 231	Probability and Statistics (3)
ECE 81	Principles of Electrical Engineering (4) **or**
Phys 31	Introduction to Quantum Mechanics (3)
Mech 1	Statics (3) General Studies elective (3)
Mat 63	Engineering Materials and Processes (3) **or**
Mat 93	Introduction to Solid State Materials (3) **or** General Studies elective (3)

junior year, first semester (18 credits)

ChE 60	Unit Operations Survey (3)
Chem 207	Metallic Elements (3)
Mech 11	Mechanics of Materials (3)

Mat 207	Crystal Structure and Atom Movements (3)
Mat 210	Metallurgical Thermodynamics (3)
	General Studies elective (3)

junior year, second semester (18 credits)

Mat 101	Professional Development (2)
Mat 208	Phase Diagrams and Transformations (3)
Mat 212	Electronic Behavior of Solids (3)
Mat 218	Mechanical Behavior of Materials (3)
Mat 304	Chemical Metallurgy (4)
	elective (3)

summer

Mat 100	Industrial Employment

senior year, first semester (18 credits)

Mat 305	Ferrous Production Metallurgy (3)
Mat 307	Materials Engineering I (3)
Mat 313	Materials Fabrication (3)
	engineering science elective (3)*
	electives (6)

senior year, second semester (18 credits)

Mat 338	Materials Reports (3)
Mat 308	Materials Engineering II (3)
	engineering science elective (3)*
	approved elective (3)
	General Studies elective (3)
	elective (3)

*Engineering science electives are selected from a list available in the department office.

In addition to the regular program, there are two options in the curriculum oriented to emphasize the following: industrial materials engineering, and preparation for graduate research in materials.

Industrial Option

The industrial option is designed to prepare students in a four-year program as plant materials engineers. To assist in this objective, students electing the option take two special courses, Mat 327 and 329, in place of an equivalent number of other specified courses. The emphasis in these courses is a team approach to the solution of actual plant problems.

The course is conducted in cooperation with local industries. Three days per week are spent at the plant of the cooperating industry on investigations of selected problems. The option is limited to a small group of seniors, selected by the department from those who apply. Summer employment is provided when possible for those who elect to initiate the program during the summer preceding the senior year.

junior year
same as regular program

summer

Mat 100	Industrial Employment

senior year, first semester (20 credits)

Mat 327	Industrial Project (4)
Mat 329	Industrial Project (4)
Mat 305	Ferrous Production Metallurgy (3)
Mat 307	Materials Engineering I (3)
Mat 313	Materials Fabrication (3)
	elective (3)

senior year, second semester (17 credits)

Mat 338	Materials Reports (2)
Mat 308	Materials Engineering II (3)
	Approved elective (3)
	General Studies elective (3)
	engineering science electives (6)*

*Engineering science electives are selected from a list available in the department office.

Research Option

For those students who may be interested in research or development, and intend to pursue graduate work, a research option is offered. In this option, students take Mat 240 and 291. Financial support may be available for those students who elect to initiate a research program during the summer preceeding the senior year. The option is limited to a small group of selected students.

junior year, second semester (20 credits)
same as regular program with the following addition:

Mat 240	Research Techniques (2)

summer

Mat 100	Industrial Employment or Undergraduate Summer Research

senior year, first semester (18 credits)

Mat 291	Undergraduate Research (3)
Mat 305	Ferrous Production Metallurgy (3)
Mat 307	Materials Engineering I (3)
Mat 313	Materials Fabrication (3)
	electives (6)

senior year, second semester (17 credits)

Mat 338	Materials Reports (2)
Mat 308	Materials Engineering II (3)
	Approved elective (3)
	General Studies elective (3)
	engineering science electives (6)*

*Engineering science electives all selected from a list available in the department office.

Undergraduate Courses

10. Materials Laboratory (1) fall
Application of equipment for laboratory study of structure and properties of materials. Prerequisite: Mat 63 or 93 previously or concurrently.

63. Engineering Materials and Processes (3) fall-spring*
Engineering materials and their properties. Methods and effect of fabrication and treatment. Application and use of materials in engineering. Primarily metals, but including plastics, ceramics, and other engineering materials. Prerequisite: Chem 21; Phys 11

92. Structure and Properties of Materials (3) spring*
A unified chemical-physical approach to the structure and properties of metallic, nonmetallic and composite materials of construction. Laboratories and lecture examples emphasizing structure, mechanical properties, and material applications. Prerequisite: Chem 21, Phys 21. Thomas

93. Introduction to Solid State Materials (3) fall-spring*
The physical and mechanical behavior of all classes of materials, including those for solid state electronic applications. Atomic, crystallographic, molecular, and microstructures. The influence of heat treatment and mechanical and chemical processing on structure and properties. Pertinent examples of various applications of materials in advanced technologies. Prerequisite: Chem 21, Phys 21 previously or concurrently.

**Only one of these courses may be applied for graduation credit by each student.*

100. Industrial Employment
In the summer following the junior year, students in metallurgy and materials engineering are required to secure at least eight weeks of experience in industrial plants or research organizations. A written report is required.

101. Professional Development (2) spring
Seminar on the role and purpose of engineering in society; the meaning of being a professional; the role of creativity, communications and decision making in the engineering process; expectations and problems of young engineers; personal goals; choosing a career. Required reading. Written reports based on library research. Prerequisite: junior standing.

For Advanced Undergraduates and Graduate Students

207. Crystal Structure and Atom Movements (3) fall
The crystalline state, imperfections, and noncrystalline state of materials. Study of structure by microscopy and x-ray diffraction. Atom movements and diffusion in solids. Prerequisite: Mat 10, previously or concurrently, and Phys 21.

208. Phase Diagrams and Transformations (3) spring
Thermodynamic basis for equilibrium. The phase rule. Equilibrium phase diagrams and nonequilibrium considerations, Solidification and solid-state phase changes. Rationalizations of microstructures. Recovery, recrystallization, and grain growth. Lectures and laboratory. Prerequisite: Mat 63 or 93; Mat 207 and Mat 210. Williams

210. Metallurgical Thermodynamics (3) fall
The applications of thermodynamic relations to metallurgical processes with emphasis on solving specific problems for processes such as metal refining, heat treating atmospheres, alloy equilibrium diagrams and others. Lectures and problem sections. Prerequisite: Math 23. Hahn

212. Electronic Behavior of Solids (3) spring
Wave mechanical description of electrons in solids. Energy bands, zone theory. Conductivity and magnetism in metals, semiconductors and insulators. Selected engineering applications. Prerequisite: Phys 21, Mat 93 or 207.

213. Materials Systems Analysis (3)
Study of application of materials science principles to the solution of materials engineering problems. Interrelation between basic concepts and the selection of complete materials systems, which consist of the fabricating process and finishing sequence, for particular design requirements. Materials covered will be metals, polymers, ceramics and composites. Not open to materials majors.Lectures and laboratory. Prerequisite: Mat 63 or equivalent. Wood

215. Processing and Properties of Ceramic Materials (3)
An introductory-level course on ceramic materials with emphasis on processing. Basic science of ceramic fabrication technology including glass, refractories, and ceramic coatings. Structure of oxides including clay minerals. Methods of characterization. Electrical, magnetic, thermal, and mechanical properties of ceramic products. Prerequisite: Chem 21, Phys 11 and Mat 63 or 93. Harmer

218. Mechanical Behavior of Materials (3) spring
Deformation and fracture behavior of materials. Elastic and plastic behavior, with emphasis on crystallographic considerations. Strengthening mechanisms in solids. Static and time-dependent fracture from metallurgical and fracture mechanics viewpoints. Fatigue failure. Prerequisite: Mech 11, Mat 207, and Mat 63 or Mat 93. Hertzberg

221. (STS 221) Materials in the Development of Man (3)
Development of materials technology and engineering from the stone age to atomic age as an example of the interaction between technology and society. In-class demonstration laboratories on composition and structure of materials. Term projects using archaeological materials and alloys. Course intended for, but not limited to, students in the humanities and secondary science education. Engineering students may not use this course for engineering science or technical elective credit. Notis

240. Research Techniques (2) spring
Study and application of methods of materials research. Design of experimental programs, analysis of data, presentation of results. Restricted to small numbers of students selected by the department chairperson.

291. Undergraduate Research (3)
Application of research techniques to a project in materials science and engineering selected in consultation with the faculty. Normally preceded by Mat 240.

304. Chemical Metallurgy (4) spring
Study of the processes of the recovery and refining of metals and metalloids. Includes chemical principles, thermochemistry and kinetics. Phases in high-temperature metallurgical systems, refractories, and combustion of fuels. Lectures plus laboratory and computing methods. Prerequisite: ChE 60, Mat 210, and Engr 1 or equivalent. Hahn

305. Ferrous Production Metallurgy (3) fall
A detailed engineering analysis of iron and steelmaking processes. Thermodynamic and kinetic aspects of these processes. Development of mathematical models of processes by computer programming. Lectures, laboratory, and plant trips. Prerequisite: Mat 304. Tarby

306. Optimization of Metallurgical Processes (3)
Numerical methods are used to investigate metallurgical reactions and processes. Problems relating to the optimization of processes in the ferrous and nonferrous fields are studied. Lectures and computer-oriented problems. Prerequisite: a knowledge of computer programming and consent of the department chairperson. Tarby

307. Materials Engineering I (3) fall
Selection of fabrication sequences for ceramic, metallic and plastic materials. Correlation of structure and properties of ferrous alloys including design of thermal treatments. Lectures plus laboratory, which includes designing and conducting original experiments to solve materials engineering problems. Term project on selecting manufacturing sequences. Plant visits. A three-day inspection trip is required. Prerequisite: Mat 208. Pense, Wood

308. Materials Engineering II (3) spring
Continuation of Met 307. Correlation of structure and properties of ceramic and plastic materials. Design of nondestructive evaluation systems. Engineering to minimize environmental degradation of materials. Selection of materials and processing to solve specific engineering problems. Failure analysis. Lectures plus laboratory, which involves development and execution of experimental projects to solve engineering problems. Term project on selecting material systems. Plant visits. Prerequisite: Mat 307. Wood, Pense

309. Composite Materials (3) fall
The principles and technology of composite materials, primarily for structural use. Fabrication and properties of fiber-reinforced materials and other composites, such as laminates and foamed and fibrous thermal insulation. Lectures and some field trips or laboratories. Prerequisite: Mat 63 or equivalent. Thomas

311. Metallic Materials for Structures (3) fall
The structure and behavior of structural steels, aluminum and other alloys, with emphasis on materials used in large-scale engineering structures such as bridges, buildings and pressure vessels. Fracture mechanics concepts, the physical metallurgy of alloys involved, and fabrication of structures, especially welding. The relationship between materials, fracture control and fabrication. Materials majors may take only with the consent of the department chairperson. Lectures and laboratory. Hertzberg, Pense

312. (ChE 312, Chem 312) Fundamentals of Corrosion (3)
Corrosion phenomena and definitions. Electrochemical aspects including reaction mechanisms, thermodynamics, Pourbaix diagrams, kinetics of corrosion processes, polarization, and

passivity. Nonelectrochemical corrosion including mechanisms, theories, and quantitative descriptions of atmospheric corrosion. Corrosion of metals under stress. Cathodic and anodic protection, coatings, alloys, inhibitors, and passivators. Prerequisite: Mat 210, Chem 187, or equivalent of either.

313. Materials Fabrication (3) fall
Basic concepts of stress, strain and stress-strain behavior under load. Analysis and description of metal forming, metal cutting, casting, joining, and powder metallurgy. Lectures and laboratory. Prerequisite: Mat 63 or equivalent. Avitzur

314. Advanced Metal Forming (3)
Extension of Met 313. Topics to be included: friction, lubrication and wear, failure and damage in metal forming, and deformation in composite metals and in powder metallurgy. Forming alternatives for specific products such as cans, tubes, wires and others will be compared. Recent developments of new forming processes. Prerequisite: Mat 313. Avitzur

315. Introduction to Physical Ceramics (3)
Methods of fabrication, physical properties, and applications of ceramic materials, including oxides, carbides, nitrides, borides and silicides. Correlation of atomic bonding, microstructure and physical behavior in service envionments. Special topics, including electronic ceramics, nuclear ceramics, refractories, cutting tools, and abrasives. Prerequisite: Chem 21 and Phys 11 or consent of the department chairperson. Harmer

316. Physical Properties of Materials (3)
Consideration of observed electrical, magnetic, thermal and optical properties of crystalline materials with emphasis on their relationship to electron configuration and crystal structure. Lectures and demonstrations. Prerequisite: Mat 207 or Phys 31, or consent of the department chairperson. Notis or Butler

317. Imperfections in Crystals (3)
The major types of crystal defects and their role in controlling the properties of materials. Point, line and planar defects, their atomic configurations and experimental techniques to study their characteristics. Emphasis on the role of dislocations and grain boundaries in the control of mechanical properties. Prerequisite: Mat 63 or 93, or equivalent. Chou and Williams

319. Current Topics in Materials Science (3)
Selected topics of current interest in the field of materials engineering but not covered in the regular courses. May be repeated for credit with consent of the department chairperson. Prerequisite: Mat 210 and 218.

320. Analytical Methods in Materials Science (3)
Selected topics in modern anaylsis and their application to materials problems in such areas as thermodynamics, crystallography, deformation and fracture, diffusion. Prerequisite: Math 231 or 205. Chou

321. (ECE 305) Failure Analysis of Semiconductor Devices (3)
Fundamental degradation and failure mechanisms that affect the reliability of seminconductor devices. The use of scanning and transmission electron microscopy to examine these mechanisms. Lectures and laboratory. Prerequisite: consent of department chairperson. Norian

322. Materials Technology in the Energy Crisis (3) spring
Impact of materials on energy including nuclear and solar energy and solar cells, coal gasification, MHD power generation and superconductors. Energy resources, conversion, and consumption. Materials limitations on development of energy alternatives in transporation, power and primary metals industries. Industry and government lecturers participate. Prerequisite: Mat 63 or consent of the deparment chairperson. Notis

323. (ECE 303) Electrical and Physical Characterization of Defects in Semiconductors
Basic concepts of solid-state physics applied to P-N junction theory. Topics will include influence of material growth techniques on defect origination; dislocations induced by diffusion; oxidation-induced stacking faults; the role of imperfections on pipe leakage and soft breakdowns. The relation of materials, defects and processing will be highlighted. Jaccodine

327. Industrial Project (4) fall
Restricted to a small group of seniors and graduate students selected by the department from those who apply. Three full days per week are spent on development projects at the plant of an area industry, under the direction of a plant engineer and with faculty supervision. Hahn, Butler

329. Industrial Project (4) fall
To be taken concurrently with Mat 327. Course material is the same as Mat 327.

333. (Geol 337, Chem 337) X-ray Diffraction of Materials (3) fall
Emphasis on materials characterization with computer-controlled powder diffractometers. Specific topics include x-ray spectroscopy, crystallographic notation, orientation of single crystals, preferred orientations in polycrystals, crystallite size measurement, phase identification, quantitative analysis of crystalline phases, and stress measurement. Applications in mineralogy, metallurgy, ceramics, microelectronics, polymers, and catalysts. Lectures and laboratory work. Prerequisite: consent of department chairperson. Lyman

334. (Geol 338) Electron Microscopy and Microanalysis (4) fall
Fundamentals and experimental methods in electron optical techniques including scanning electron microscopy (SEM) conventional transmission (TEM) and scanning transmission (STEM) electron microscopy. Specific topics covered will include electron optics, electron beam interactions with solids, electron diffraction and chemical microanalysis. Applications to the study of the structure of materials are given. Prerequisite: consent of the department chairperson. Williams, Lyman

335. (ChE 335) Principles of Semiconductor Materials Processing (3) fall
Description and analysis of the processing steps involved in microelectronic material fabrication. Emphasis will be placed on the chemistry of the fabrication steps, mathematical modelling of the transport and chemical reaction phenomena, and interpretation of experimental methods and data. Prerequisite: a course in thermodynamics and senior standing.

338. Materials Reports (2 or 3) spring
Presentation of oral and written reports. Evaluation on both technical content and quality of presentation. Oral reports alone—2 credits; including written reports—3 credits. Prerequisite: senior standing.

343. (ChE 393, Chem 393) Physical Polymer Science (3)
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline and paracrystalline states (including viscoelastic and relaxation behavior) for single and multicomponent systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology and behavior. Prerequisite: one year of physical chemistry.

345. Nondestructive Evaluation (3)
Scientific fundamentals and engineering applications of nondestructive evaluation methods including penetrant, magnetic particle, eddy-current, radiographic, ultrasonic and acoustic-emission inspection techniques. Recent developments in nondestructive inspection of materials. Lectures and labs. Prerequisite: Mat 63 or equivalent, senior standing. Wood

396. (Chem 396) Chemistry of Nonmetallic Solids (3) Chemistry of ionic and electronic defects in nonmetallic solids and their influence on chemical and physical properties. Intrinsic and impurity-controlled defects, nonstoichiometric compounds, defect interaction. Properties to be discussed include; diffusion, sintering, ionic and electronic conductivity, solid-state reactions, and photoconductivity. Prerequisite: Chem 187 or Mat 210 or equivalent. Smyth

For Graduate Students

The department offers three degrees; a master of science, a master of engineering, and a doctor of philosophy in metallurgy and materials engineering.

While a diversity of programs and curricula are available to a person interested in graduate study in the area of materials, generally the degree is earned in the department of materials science and engineering. However, thesis and dissertation research may be a part of programs under way in the department or at the Materials Research Center or other departments or centers.

The department has a large enough staff and graduate enrollment to enable it to suit the needs of students whose interests range from the science of materials through materials engineering. At the same time, those advanced students who want experience in teaching are able to teach under the guidance of the senior staff.

The foundation for successful graduate work in the department includes sound preparation in chemistry, physics and mathematics, and adequate breadth of general education. Candidates entering the department who have obtained their previous degrees in fields other than materials may be required to take certain undergraduate courses without credit toward the graduate degree.

The programs of the department are flexible. Upon acceptance, each student is assigned a faculty adviser. Under the adviser's direction, the student plans a course of study to satisfy individual needs and interests.

Most advanced-degree recipients find careers in industry or industrial or governmental research and development laboratories. A smaller number have gone into teaching, consulting or academic research.

Graduate facilities for research are located in the Whitaker Laboratory, in the interdisciplinary Materials Research Center, the Sherman Fairchild Laboratory, and other associated laboratories. The laboratories are well equipped with both generalized equipment as well as sophisticated research equipment.

Specialized equipment such as conventional and scanning transmission electron microscopes, scanning electron microscopes, electron microprobe, X-ray diffraction units, closed-loop mechanical testing equipment, and crystal-growing and zone-processing equipment are maintained and operated by skilled technicians. After receiving the required instructions, graduate students operate this equipment.

Departmental facilities are supplemented by central computer facilities, microcomputers, and a fine science and engineering library.

Special Programs and Opportunities

The department has established specific recommended programs for the M.S., the M. Eng., and the Ph.D., emphasizing the following areas: electron microscopy and microanalysis of all materials, physical metallurgy, ceramics, polymers and composites, mechanical behavior, electronic materials, and manufacturing processes.

These programs are flexible. Students in an area such as fracture may work in the department or in cooperation with the Materials Research Center or the department of mechanical engineering. The ceramics program emphasizes the study of the electrical and mechanical behavior of various ceramic systems. The study of solid-state materials for electronic applications is done largely in the Sherman Fairchild Laboratory. The department also cooperates with the chemical engineering and chemistry departments in the graduate Polymer Science and Engineering Program.

Major Requirements

The Graduate School requirements are explained in Section IV. In the department of materials science and engineering, a candidate for the M.S. completes a thesis. This normally represents six of the thirty semester hours required for this degree. Candidates for the M.Eng. complete a three-credit engineering project.

A candidate for the Ph.D. prepares a preliminary program of courses and research, providing for specialization in some phase of the field (largely through research) in consultation with the adviser. Prior to formal establishment of the doctoral program by the special committee and its approval by The Graduate School, the student passes a qualifying examination that must be taken early in the first year of doctoral work. The department does not require a foreign language. It does require preparation and defense of a research proposal as a portion of the general examination.

Of the courses listed above only those in the 300 series are available for graduate credit. There are many additional offerings in materials under the listings of other departments.

Most graduate students receive some form of financial aid. Several kinds of fellowships and assistantships are available. This type of aid generally provides for tuition, an allowance for experimental supplies, and a stipend. For details of graduate scholarships, fellowships and assistantships, please refer to Section IV.

Research Activities

Graduate students conduct their research in facilities located in the department or the Materials Research Center, or other centers and institutes. The following list of activities notes the many areas of interest. Asterisks (*) indicate research of an interdisciplinary nature.

Materials science. Crystal growth*; defect chemistry and electrical properties of insulating and semiconducting oxides*; growth and deformation of bicrystals; dislocation studies; meteorites and lunar materials; processing of metal insulator semiconductor structures and their evaluation and application to integrated circuits*; quantitative metallography; structure and behavior of solid-state materials*.

Mechanical behavior. Correlation of microstructure with mechanical behavior of low-alloy, high-strength steels; deep drawing, impact extrusion and ironing; electron fractography*; environmental crack kinetics*; fatigue crack propagation studies of metals and polymers*; flow through converging conical dies; friction measurement; theoretical analysis of metal-forming methods and correlation with metallurgical parameters; toughness of weld metal; weldability of steels.

Ceramics. Electrical properties of electronic ceramics*; hot pressing studies*; grain growth in oxides*; electrical and magnetic properties of oxides*; creep modeling of ceramics*; electron microscopy of dislocation structures*; defect chemistry and electrical properties of ceramic oxides and glasses.*

Physical metallurgy. Brittle fracture characteristics and fatigue properties of low-alloy, high-strength steels*; diffusion-controlled growth; kinetics of solid-state reactions*; physical metallurgy of aluminum alloys; strengthening mechanisms; structure and morphology of martensite; ternary diffusion; transformation during joining; transmission electron microscopy of crystal defects.

Polymers. Environmental effects on polymers*; fatigue crack propagation in engineering plastics*; fracture surfaces of crystalline polymers*; ion transport in polymer membranes; mechanical behavior of interpenetrating networks*; mechanical behavior of polyvinyl chloride*; micromechanics of polymer fracture*; polymers from renewable resources; properties of polymer composites*; reclamation of scrap polymeric materials*; viscoelastic damping.

Chemical metallurgy. Mathematical modeling of metallurgical processes; thermodynamics of metallic solutions; thermodynamics and phase equilibria.

Graduate-Level Courses

406. Solidification (3)
Structure, theory and properties of liquids. Homogeneous and heterogeneous nucleation theory and experimental results. Solidification phenomena in pure, single and multiphase materials including the nature of the freezing interface, segregation, constitutional super-cooling, dendritic growth, crystallographic effects, the origin of defects, crystal growing, zone processes. Prerequisite: consent of the chairperson. Kraft

407. Theory of Alloy Phases (3)
Equilibrium portrayal and prediction. For the former, the emphasis is on systems of three of more independent variables. For the latter, consideration is given to the various factors, both 'physical' and thermodynamic, which influence, and may permit prediction of, equilibrium phase structures and their range of stability. Examples are considered of the extension of such approaches to property prediction. Prerequisite: an undergraduate course in equilibrium diagrams, e.g. Mat 208.

408. Transformations (3) fall
The thermodynamic, kinetic and phenomenological aspects of a wide spectrum of solid-state phase transformations. Theories of nucleation, growth and coarsening of second-phase precipitates. Application of the theories to continuous and discontinuous reactions, massive, martensitic and bainitic transformations in metals. Transformations in non-metallics. Prerequisite: Mat 208 and 210 or equivalent. Marder

409. Current Topics in Materials (3)
Recent practical and theoretical developments in materials. This course may be repeated for credit if new material is covered. Prerequisite: consent of the department chairperson.

410. Physical Chemistry of Metals I (3) fall
Discussions of reactions involving gases and reactions involving pure condensed phases and a gaseous phase. Ellingham diagrams and equilbria in metal-oxygen-carbon systems. Consideration of the behavior of solutions and methods for determining thermodynamic properties of solutions by experimentation and computation. Prerequisite: Mat 210 or equivalent. Tarby

411. Modern Joining Methods (3)
The foundations upon which the joining processes rest; the present limitations of the various processes; the trends in new developments; the engineering and structural aspects of joining. Prerequisite: Mat 208 and 218 or equivalent. Pense

412. Magnetic Properties of Materials (3)
Fundamental concepts of magnetism and magnetic properties of ferro- and ferrimagnetic materials. Metallic and nonmetallic materials. Current application areas considered as examples. Prerequisite: Phys 31 or 363 or equivalent. Butler or Notis

413. Analysis of Metal Forming Processes (3)
Three-dimensional stress and strain analysis. Yield criteria, plastic flow and the upper and lower bound theorems. Analysis of metal forming processes, including drawing and extrusion, press work, rolling and spinning. The emphasis is on presenting several approaches to each problem. Avitzur

414. Physical Chemistry of Metals II (3) spring
Presentation of free energy-composition and phase diagrams of binary systems. Evaluation of lattice stability parameters. Consideration of reaction equilibria in systems containing components in condensed solutions, including compound formation, oxide phases of variable composition, solubility of gases in metals. Alternative standard states and interaction parameters for solutions. Prerequisite: Mat 410. Tarby

415. Mechanical Behavior of Ceramic Solids (3)
Strength, elasticity, creep, thermal stress fracture, hardness, abrasion and high-temperature deformation characteristics of single- and multi-component brittle ceramic solids. Statistical theories of strength, static and cyclic fatigue, crack propagation, fracture toughness. Correlation of mechanical behavior, microstructure, and processing parameters. Prerequisite: Mat 218 or consent of the department chairperson. Notis, Harmer

416. Atom Movements (3)
Phenomenological and atomistic development of the laws of diffusion and their solution. Influence of gradients of concentration, potential, temperature and pressure. Effects of structural defects on diffusion in metals and nonmetals. Prerequisite: Math 23 and Chem 196 or the equivalent.

417. Deformation and Strength of Solids (3)
Topics related to deformation of solids including creep, strengthening mechanisms, annealing of deformed solids, preferred orientation. Primary emphasis is on crystalline materials. May be repeated for credit if different material is covered. Prerequisite: Mat 218 or equivalent. Chou, Hertzberg, Kraft or Notis

418. Fatigue and Fracture of Engineering Materials (3) fall
Application of fracture mechanics concepts to the fatigue and fracture of crystalline and amorphous solids. Fracture control design philosophies. Metallurgical aspects of fracture toughness and embrittlement susceptibility. Environment-enhanced cracking. Fatigue crack propagation in metals and polymers. Electron fractography. Failure anaylsis case histories. Prerequisite: Mat 218 or equivalent. Hertzberg

419. Advanced Physical Metallurgy (3)
Application of physical metallurgy principles to materials systems. Transformation structures and the influence of morphology on properties. Alloy design and heat treatment for improved strength, toughness, creep, corrosion resistance, electrical and magnetic properties. Prerequisite: Mat 307 or equivalent. Marder

421. Fracture Analysis (3)
Application of fracture mechanics concepts, microstructural analysis, and fracture surface characterization to the analysis and prevention of engineering component failures. Extensive use of case histories. Introduction to legal aspects of product liability. Prerequisite: Mat 218 or 311 or Mech 313 or equivalent. Hertzberg

422. Electrical Properties of Materials (3)
Electrical transport properties of metallic, semiconducting and insulating materials. Brief review of energy band concepts including surface and contact effects. Photoconduction and contact phenomena. Prerequisite: Phys 31 or 363 or equivalent. Butler or Notis

423. Advanced Transmission Electron Microscopy (3)
The theory and practice of operation of the transmission and scanning transmission electron microscope. Techniques covered include bright field, high resolution and weak-beam dark field, lattice imaging, diffraction pattern indexing and Kikuchi line analysis. The theory of diffraction contrast is applied to the interpretation of electron micrographs. Specimen preparation techniques. Prerequisite: Mat 334 or equivalent. Williams

425. Topics in Materials Processing (3)
Topics such as: ceramics, metal, and polymer synthesis and compaction phenomena. Theories of sintering and grain growth. Physical behavior of sintered compacts. Techniques of fiber and crystal growth. Vapor deposition and ultra-high-purity materials preparation. Desirable preparation: Mat 208, 218, 315. Prerequisite: consent of the department chairperson.

427. Advanced Scanning Electron Microscopy (3)
The theory and practice of operation of the scanning electron microscope and electron microprobe. Techniques covered will include high-resolution scanning, quantitative electron probe microanalysis. Electron beam sample interactions, X-ray spectrometry, and electron optics will be discussed in detail. Prerequisite: Mat 334 or equivalent.

429. Dielectric and Electrical Properties of Ceramics (3)
Basic concepts of dielectric and electrical phenomena in ceramics including dielectric loss, dielectric breakdown, ferroelectricity, piezoelectricity, mixed conduction, and interfacial effects. Physical and materials aspects of technologically important ceramics such as thermistors, varistors, boundary layer capacitors, solid electrolytes, gas sensors, glasses etc. Prerequisite: Mat 212 or equivalent. Jain

437. (Mech 437) Dislocations and Strength in Crystals (3)
Theory and application of dislocations. Geometrical interpretation; elastic properties; force on a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Selected topics in strengthening, plastic flow, creep, fatigue and fracture are discussed. Prerequisite: Math 205 or 231, or Mat 320; Mat 317, or consent of the department chairperson. Chou, Wei

443. (Chem 443) Solid-State Chemistry (3)
Crystal structure, diffraction in crystals and on surfaces, bonding and energy spectra in solids, dielectrics, surface states and surface fields in crystals. Prerequisite: Chem 191 or equivalent. Klier

458. Materials Design (3)
Analysis of design requirements for materials components. Selection of materials and processes. Study of failures in process and service and application of recent metallurgical and materials engineering knowledge for improved design. Solution and discussion of industrial problems, and outline of experimental approach. Prerequisite: consent of the chairperson. Wood

460. Engineering Project (1-3)
In-depth study of a problem in the area of materials engineering or design. The study is to lead to specific conclusions and be embodied in a written report. Intended for candidates for the M.Eng. May be repeated for a total of three credit hours.

461. Advanced Materials Research Techniques (3)
Study of the theory and application of selected advanced techniques for investigating the structure and properties of materials. May be repeated for credit with the approval of the department chairperson.

482. (Chem 482, ChE 482) Engineering Behavior of Polymers (3) spring
A treatment of the mechanical behavior of polymers. Characterization of experimentally observed viscoelastic response of polymeric solids with the aid of mechanical model analogs. Topics include time-temperature superposition, experimental characterization of large deformation and fracture processes, polymer adhesion, and the effects of fillers, plasticizers, moisture and aging on mechanical behavior.

485. (Chem 485, ChE 485) Polymer Blends and Composites (3) fall
An intensive study of the synthesis, morphology, and mechanical behavior of polymer blends and composites. Mechanical blends, block and graft copolymers, interpenetrating polymer networks, polymer impregnated concrete, and fiber and particulate reinforced polymers are emphasized. Prerequisite: any introductory polymer course or equivalent.

Mathematics

Professors. Eric P. Salathe, Ph.D. (Brown), *chairman, director of the Division of Bioengineering at the Center for Health Sciences;* Edward F. Assmus, Jr., Ph.D. (Harvard); Donald M. Davis, Ph.D. (Stanford); Bennett Eisenberg, Ph.D. (M.I.T.); B. K. Ghosh, Ph.D. (London); Samuel L. Gulden, M.A. (Princeton); Samir A. Khabbaz, Ph.D. (Kansas); Jerry P. King, Ph.D. (Kentucky), *dean of the Graduate School;* Gregory T. McAllister, Ph.D. (Berkeley), *head of the Division of Applied Mathematics and Statistics;* George E. McCluskey, Ph.D. (Pennsylvania), *head of the Division of Astronomy;* Murray Schechter, Ph.D. (N.Y.U.); Gerald F. Smith, Ph.D. (Brown), *director of the Center for the Application of Mathematics;* Andrew K. Snyder, Ph.D. (Lehigh); Gilbert A. Stengle, Ph.D. (Wisconsin); Albert Wilansky, Ph.D. (Brown), *University Distinguished Professor.*
Associate professors. David L. Johnson, Ph.D. (M.I.T.); Jacob Y. Kazakia, Ph.D. (Lehigh); Clifford S. Queen, Ph.D. (Ohio State); Gerhard Rayna, Ph.D. (Princeton); Ramamirtham Venkataraman, Ph.D. (Brown).
Assistant professors. Bruce A. Dodson, Ph.D. (S.U.N.Y. at Stony Brook); Wei-Min Huang, Ph.D. (Rochester); Lee J. Stanley, Ph.D. (Berkeley); Susan Szczepanski, Ph.D. (Rutgers); Charles H. Voas, Ph.D. (Virginia); Daniel J. Yaniro, Ph.D. (Northwestern); Joseph E. Yukich, Ph.D. (M.I.T.).
Visiting faculty. Daniel Waggoner, Ph.D. (Kentucky).

Mathematics is the universal language of science, and is essential for a clear and complete understanding of virtually all phenomena. Mathematical training prepares a student to express and analyze problems and relationships in a logical manner in a wide variety of disciplines including the physical, engineering, social, biological, and medical sciences, business, and pure mathematics itself. This is a principal reason behind the perpetual need and demand for mathematicians in education, research centers, government, and industry.

The department offers two major programs leading to the degrees of bachelor of arts in mathematics and bachelor of science in statistics. It also offers five minor programs for undergraduates.

The Division of Astronomy and the Division of Applied Mathematics and Statistics are parts of the Department of Mathematics. Details on these divisions may be found in separate listings in the catalog.

Calculus Sequences

There are three calculus sequences: Math 21, 22, 23; Math 31, 32; Math 41, 44. The first sequence should be taken by those students who might go into engineering, mathematics or the natural and physical sciences. The first sequence will always be accepted in place of Math 41 and 44, but not vice versa. Math 41, 42, 43 and 44 are designed primarily for students of the biological, management, and social sciences (BMSS); Math 44 should normally be taken in the semester following Math 41, but Math 42 and 43 may be taken at any time. Math 31 and 32 constitute an accelerated calculus sequence that is at least equivalent to the Math 21, 22, 23 sequence. Enrollment in Math 31 and 32 is limited to those students who have demonstrated exceptional ability in pre-university mathematics. A grade of C- or better in Math 32 entitles a student to receive twelve credit hours for eight hours of work in Math 31 and 32. Credit will be awarded for only one course in each of the following three groups, A: 21, 31, 41, B: 22, 32, 44, C: 23, 32, when more than one course is taken in any group, credit will be given for the course with the maximum hours.

B.A. in Mathematics

The B.A. program in mathematics emphasizes fundamental principles as well as the mastery of techniques required for the effective use of mathematics. The program has the flexibility and versatility needed to prepare students for careers in government, industry and education. The program provides a solid foundation for those who want to pursue advanced study in any mathematically oriented field.

The program involves a total of 120 credit hours, 42 of which are in required major courses listed below. The remaining 78 credit hours are for college and university requirements , general electives,
and any additional mathematics courses that a student may wish to take.

Required Major Courses (42 credit hours)

Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12)
Math 205	Linear Methods (3)
Math 219, 220	Principles of Analysis I and II (6)
Math 243	Algebra (3)
Math 244	Linear Algebra (3)
Math 316	Complex Analysis (3)
Math	Electives (12)

Note: Math 21, 22, 23 may be replaced by Math 31, 32. The twelve hours of electives must be approved by the student's major advisor. The electives must include at least two of the following courses: Math 230, 231, 303, 307, 320 and 342. A student must achieve an average of 2.0 or higher in major courses.

B.S. in Statistics

Statistics is concerned with the development and application of techniques for collecting, analyzing and interpreting data in such a way that the reliability of the conclusions can be quantified. Statistical analysis thus forms a fundamental tool in all experimental sciences and is important in understanding chance phenomena. Mathematical principles, especially probability theory, underlie all statistical analyses.

The B.S. program in statistics is interdisciplinary, and is a cooperative effort of faculty members from several departments. A student participating in the program is enrolled in the department of mathematics and is assigned a faculty advisor whose departmental affiliation depends on the student's needs and interests.

The program involves a total of 120 credit hours, which are divided into four parts.

College and University Requirements (36 credit hours)

Required Major Courses (43 credit hours)

Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12)
Math 7	Elements of Statistics (3)
Math 205	Linear Methods (3)
Math 309	Theory of Probability (3)
Math 310	Probability and Its Applications (3)
Math 334	Mathematical Statistics (3)
Math 374	Statistical Project (3)
CSc 11	Introduction to Structured Programming (3)
CSc 15	Data Structures (4)
IE 333	Sampling for Information (3)
IE 336	Analysis of Experimental Data (3)

Note: Math 21, 22, 23 may be replaced by Math 31, 32, and Math 7 may be replaced by Math 231 or Eco 145. A student must achieve an average of 2.0 or higher in major courses.

Major Electives (12 credit hours)
Four courses chosen from: Math 208, 219, 244, 313, 344, IE 206, 332, Mkt 463.

Professional Electives (29 credit hours)
These are to be selected from at least two fields of application of statistics and probability, such as biology, psychology, social relations, computer science, engineering, economics, and management.

The major and professional electives must be approved by the faculty advisor.

Minor Programs

The department offers five minor programs in different branches of the mathematical sciences. The minors are designed to provide recognition to those students who take a program of study in mathematics or a related area in addition to their major requirements in the engineering, arts and science or business curricula.

Each program requires twelve credit hours of work shown below, and Math 23 or 32. For substitutions, the student should consult the chairman.

Minor in Pure Mathematics
Math 219, 243, 244
Math 220 or 303 or 307 or 316 or 342

Minor in Applied Mathematics
Math 205 or 244
Math 208, 322
Math 230 or 231 or 320 or 323 or 344

Minor in Probability and Statistics
Math 7 and 309, or Math 42 and 231, or Math 231 and 309
Any two of Math 310, 313, 334

Minor in Actuarial Science
Math 205, 230, 231
Math 309 or 334 or 344
For information on examinations of actuarial societies, students may consult their minor advisor.

Minor in Astronomy
Phys 21, Astr 2
Astr 211 or 221
Astr 232 or 242

Undergraduate Courses

0. Precalculus (0)
Review of the elementary mathematics needed to study calculus. No academic credit. Usually offered in the summer.

5. Introduction to Mathematical Thought (3) spring
Meaning, content, and methods of mathematical thought illustrated by topics that may be chosen from number theory, abstract algebra, combinatorics, finite or non-Euclidean geometries, game theory, mathematical logic, set theory, topology.

7. Elements of Statistics (3) fall
Statistical data and frequency distributions; probability, random variables, and sampling distributions; estimation, confidence intervals, and hypothesis testing; regression and correlation; analysis of variance. Illustrations from biological, engineering, physical and social sciences.

21. Analytic Geometry and Calculus I (4) fall-spring
Functions and graphs; limits and continuity; derivative, differential, and applications; Taylor's Theorem and other approximations; indefinite and definite integrals; trigonometric, logarithmic, exponential, and hyperbolic functions.

22. Analytic Geometry and Calculus II (4) fall-spring
Applications of integration; techniques of integration; separable differential equations; infinite sequences and series; curves and vectors in the plane. Prerequisite: Math 21 or Math 31.

23. Analytic Geometry and Calculus III (4) fall-spring
Vectors in space; partial derivatives; Lagrange multipliers; multiple integrals; vector analysis; exact differential equations and second-order differential equations with constant coefficients. Prerequisite: Math 22.

31. Honors Calculus I (4) fall
Functions and graphs; limits and continuity; derivative and differential; indefinite and definite integrals, logarithmic; exponential, trigonometric and hyperbolic functions; techniques and applications of integration. Math 31 may be used in place of Math 21 to satisfy prerequisites. Prerequisite: consent of the department chairman.

32. Honors Calculus II (4) spring
Vector calculus; solid analytic geometry; series; Taylor's Theorem; approximations; partial derivatives; multiple integrals; line and surface integrals; differential equations. Prerequisite: Math 31 or consent of the department chairman.

41. BMSS Calculus I (3) fall-spring
Functions including the exponential, logarithmic, and trigonometric functions; limits; continuity; differentiation with applications to maximum and minimum problems; antidifferentiation.

42. BMSS Probability (3) spring
Sets, functions, counting methods, probability spaces, conditional probability and independence, random variables, continuous probability spaces, some useful probability distributions-binomial, hypergeometric, Poisson, uniform, exponential and normal.

43. BMSS Linear Algebra (3) fall
Matrices, vectors, vector spaces and mathematical systems, special kinds of matrices, elementary matrix transformations, systems of linear equations, convex sets, introduction to linear programming.

44. BMSS Calculus II (3) fall-spring
Indefinite and definite integrals and the fundamental theorem of calculus with applications; numerical integration; elementary differential equations; functions of several variables and partial derivatives with applications to extremal problems. Prerequisite: Math 41 or Math 21 or consent of the department chairman.

171. Readings (1-3) fall-spring
Study of a topic in mathematics under individual supervision. Intended for students with specific interests in areas not covered in the listed courses. Prerequisite: consent of the department chairman.

For Advanced Undergraduates and Graduate Students

For students who have not taken their elementary mathematics at Lehigh, the prerequisites for certain advanced courses are stated in terms of the number of credit hours of calculus.

205. Linear Methods (3) fall-spring
Linear differential equations and applications; matrices and systems of linear equations; vector spaces; eigenvalues and application to linear systems of differential equations. Prerequisite: Math 23 or Math 32 or nine semester hours of differential and integral calculus.

207. (ChE 207) Introduction to Biomedical Engineering and Mathematical Physiology (3) fall
Topics in human physiology and mathematical analysis of physiological phenomena, including the cardiovascular and respiratory systems, biomechanics, and renal physiology; broad survey of bioengineering. Independent study projects. Prerequisite: Math 205.

208. Complex Variables (3) fall-spring
Functions of a complex variable; calculus of residues; contour integration; applications to conformal mapping and Laplace transforms. Prerequisite: Math 23 or Math 32.

219. Principles of Analysis I (3) fall
Existence of limits, continuity and uniform continuity; Heine-Borel Theorem; existence of extreme values; mean value theorem and applications; conditions for existence of the Riemann integral; absolute and uniform convergence; emphasis on theoretical material from the calculus of one variable. Prerequisite: Math 23 or Math 32.

220. Principles of Analysis II (3) spring
Continuation of Math 219. Functions of several variables; line and surface integrals; implicit functions. Prerequisite: Math 219.

230. Numerical Methods (3) fall-spring
Representation of numbers and rounding error; numerical solution of equations; quadrature; polynomial and spline interpolation; numerical solution of initial and boundary value problems. Prerequisites: Math 205 (previously or concurrently) and knowledge of either FORTRAN or PASCAL.

231. Probability and Statistics (3) fall-spring
Probability and distribution of random variables; populations and random sampling; chi-square, t, and F distributions; estimation and tests of hypotheses; correlation and regression theory of two variables. Prerequisite: Math 23 or Math 32 or Math 44.

243. Algebra (3) spring
Introduction to basic concepts of modern algebra: groups, rings, and fields.

244. Linear Algebra (3) fall
Thorough treatment of the solution of m simultaneous linear equations in n unknowns, including a discussion of the computational complexity of the calculation. Vector spaces, linear dependence, bases, orthogonality, eigenvalues. Application as time permits. Prerequisite: Math 43 or Math 205 or Math 243.

261. (CSc 261) Discrete Structures (3)
Topics in discrete mathematical structures chosen for their applicability to computer science and engineering. Sets, propositions, induction, recursion; combinatorics; binary relations and functions; ordering, lattices and Boolean algebra; graphs and trees; groups and homomorphisms. Prerequisites: Math 21, and either CSc 11 or Engr 1.

303. Mathematical Logic (3) fall
A course, on a mathematically mature level, designed not only to acquaint the student with logical techniques used in mathematics but also to present symbolic logic as an important adjunct to the study of the foundations of mathematics.

304. Axiomatic Set Theory (3) spring
A development of set theory from axioms; relations and functions; ordinal and cardinal arithmetic; recursion theorem; axiom of choice; independence questions. Prerequisite: Math 219 or consent of the department chairman.

307. General Topology I (3) fall
An introductory study of topological spaces, including metric spaces, separation and countability axioms, connectedness, compactness, product spaces, quotient spaces, function spaces. Prerequisite: Math 219.

308. Algebraic Topology (3) spring
Polyhedra, fundamental groups, simplicial and singular homology. Prerequisites: Math 307 and either Math 243 or Math 327.

309. Theory of Probability (3) fall
Probabilities of events on discrete and continuous sample spaces; random variables and probability distributions; expectations; transformations; simplest kind of law of large numbers and central limit theorem. The theory is applied to problems in physical and biological sciences. Prerequisite: Math 23 or Math 32 or Math 44.

310. Probability and Its Applications (3) spring
Continuation of Math 309. Random variables, characteristic functions, limit theorems; stochastic processes, Kolmogorov equations; Markov chains, random walks. Prerequisite: Math 309 or consent of the department chairman.

313. Nonparametric Statistics (3) fall
Order and rank statistics; tests based on runs, signs, ranks, and order statistics; chi-square and Kolmogorov-Simirnov tests for goodness of fit; the two-sample problem; confidence and tolerance intervals. Prerequisite: Math 231 or 309.

316. Complex Analysis (3) spring
Concept of analytic function from the points of view of the Cauchy-Riemann equations, power series, complex integration, and conformal mapping. Prerequisite: Math 219.

320. Ordinary Differential Equations (3) spring
The analytical and geometric theory of ordinary differential equations, including such topics as linear systems, systems in the complex plane, oscillation theory, stability theory, geometric theory of nonlinear systems, finite difference methods, general dynamical systems. Prerequisite: Math 205, or both Math 23 and Math 244.

322. Methods of Applied Analysis I (3) fall
Fourier series, eigenfunction expansions, Sturm-Liouville problems, Fourier integrals and their application to partial differential equations; special functions. Emphasis is on a wide variety of formal applications rather than logical development. Prerequisite: Math 205 or consent of the department chairman.

323. Methods of Applied Analysis II (3) spring
Green's functions; integral equations; variational methods; asymptotic expansions, method of saddle points; calculus of vector fields, exterior differential calculus. Prerequisite: Math 322.

325. Computational Matrix Theory (3)
Numerical matrix algebra; algorithms for solving linear systems; symmetric and non-symmetric eigenvalue problems; least squares; functions of matrices. Students will apply these methods using either FORTRAN or PASCAL. Prerequisites: Math 205 or Math 244, and knowledge of FORTRAN or PASCAL.

327. Groups and Rings (3) fall
An intensive study of the concepts of group theory including the Sylow theorems, and of ring theory including unique factorization domains and polynomial rings. Prerequisite: Math 243 or consent of the department chairman.

334. Mathematical Statistics (3) spring
Populations and random sampling; sampling distributions; theory of statistical estimation; criteria and methods of point and interval estimation; theory of testing statistical hypotheses. Prerequisite: Math 231 or Math 309.

338. Regression and Design of Experiments (3) spring
Comparison of data sets, analysis of variance, linear models and regression, experimental designs, robust statistical analysis; use of packaged computer programs for statistical analysis. Prerequisite: Math 7 or Math 231.

340. (CSc 340) Design and Analysis of Algorithms (3) spring
Algorithms for searching, sorting, counting, graph and tree manipulation, matrix multiplication, scheduling, pattern matching and fast Fourier transforms. Abstract complexity measures and the intrinsic complexity of algorithms and problems in terms of asymptotic behavior; correctness of algorithms. Prerequisites: Math 23 and CSc 15, or consent of the department chairman.

341. Mathematical Models and Their Formulation (3) spring
Mathematical modelling of engineering and physical systems with examples drawn from diverse disciplines such as traffic flow, laser drilling, mold solidification, rocket design and business planning. Prerequisite: Math 205.

342. Number Theory (3)
A survey of elementary and nonelementary algebraic and analytic methods in the theory of numbers. Includes the Euclidean algorithm, Diophantine equations congruences, quadratic residues, primitive roots, number-theoretic functions as well as one or more of the following topics: distribution of primes, Pell's equation, Fermat's conjecture, partitions. Prerequisite: Math 219 or consent of the department chairman.

344. Linear and Integer Programming (3)
Origin of linear and integer programming problems. Solution of linear programming problems by the simplex algorithm and some of its variants. Duality theory. Solution of integer programming problems by cutting plane and branch and bound methods. Applications to economics, game theory and combinatorial problems. Prerequisite: Math 205, or both Math 23 and Math 244.

347. Problem Solving (1) fall-spring
Required of all first year graduate students. Emphasis on problems in analysis, linear algebra, and applications may be repeated for credit with consent of the department chairman. Prerequisites: Math 219 and Math 244.

350. Special Topics (3) fall-spring
A course covering special topics not sufficiently covered in listed courses. Prerequisite: consent of the department chairman. May be repeated for credit.

371. Readings (1-3) fall-spring
The study of a topic in mathematics under appropriate supervision, designed for the individual student who has studied extensively and whose interests lie in areas not covered in the listed courses. Prerequisite: consent of the department chairman. May be repeated for credit.

374. Statistical Project (3)
Supervised field project or independent reading in statistics or probability. Prerequisite: consent of the department chairman.

Graduate Programs in Mathematics

The department offers graduate programs leading to the degrees of master of science in mathematics and the doctor of philosophy in mathematics.

To begin graduate work in mathematics a student must present evidence of adequate undergraduate preparation. The undergraduate program should have included a year of advanced calculus, a semester of linear algebra, and a semester of abstract algebra.

M.S. in Mathematics

The master's program demands thirty credit hours of graduate courses with at least eighteen hours at the 400 level. With the permission of the chairman, up to six hours of these courses can be replaced by a thesis. All students in the master's program must also pass a comprehensive examination.

With a judicious choice of courses a student in the master's program can specialize in pure mathematics, applied mathematics, or statistics. The M.S. degree can serve both as a final degree in mathematics or as an appropriate background for the Ph.D. degree.

Ph.D. in Mathematics

The plan of work toward the doctor of philosophy degree will include a comprehensive examination and a qualifying examination. The latter tests the student's command of some of the following areas: analysis, functional analysis, algebra, combinatorial theory, geometry, topology, probability, statistics, logic, numerical analysis, and differential equations. A general examination, a foreign language examination, and the doctoral dissertation and its defense complete the work for the Ph.D. degree.

The department accepts candidates for the Ph.D. who desire to specialize in any of the areas listed above. Each candidate's plan of work must be approved by a special committee of the department. Although there are no specific course requirements, the Ph.D. candidates normally take several courses related to their area of specialization.

Graduate Courses

401. Real Analysis I (3) fall
Metric spaces; Lebesgue measure, integration and differentiation; L^p spaces; functions of bounded variation; and absolute continuity. Prerequisites: Math 220 and Math 307, or consent of the department chairman.

402. Real Analysis II (3) spring
Continuation of Math 401. Topics such as general theory of integration, Radon-Nikodym theorem, Fourier analysis, measures on topological spaces and Riesz representation theorems. Prerequisite: Math 401.

404. Mathematical Logic (3)
Topics in quantification theory relevant to formalized theories, recursive functions, Gödel's incompleteness theorem; algorithms and computability.

405. Partial Differential Equations I (3) fall
Classification of partial differential equations; methods of characteristics for first order equations; methods for representing solutions of the potential, heat, and wave equations, and properties of the solutions of these equations; maximum principles. Prerequisite: Math 220 or its equivalent.

406. Partial Differential Equations II (3) spring
Continuation of Math 405. Emphasis on second order equations with variable coefficients and systems of first order partial differential equations. Prerequisite: Math 405.

409. Mathematics Seminar (1-6) fall
An intensive study of some field of mathematics not offered in another course. Prerequisite: consent of the department chairman.

410. Mathematics Seminar (1-6) spring
Continuation of the field of study in Math 409 or the intensive study of a different field. Prerequisite: consent of the department chairman.

416. Complex Function Theory (3) fall
Continuation of Math 316. Prerequisite: Math 316 or consent of the department chairman.

419. Linear Operators on Hilbert Space (3)
Algebra and calculus of bounded and unbounded operators on Hilbert space; spectral analysis of self-adjoint, normal, and unitary operators. Interplay between operator theory and classical function theory is emphasized. Prerequisites: Math 220, and Math 208 or Math 316.

423. Differential Geometry I (3)
Differential manifolds, tangent vectors and differentials, submanifolds and the implicit function theorem. Lie groups and Lie algebras, homogeneous spaces. Tensor and exterior algebras, tensor fields and differential forms, de Rham cohomology, Stoke's theorem, the Hodge theorem. Prerequisite: Math 219, 220, or Math 243 or Math 244 or Math 205 with consent of instructor.

424. Differential Geometry II (3)
Curves and surfaces in Euclidean space; mean and Gaussian curvatures, covariant differentiation, parallelism, geodesics, Gauss-Bonnet formula. Riemannian metrics, connections, sectional curvature, generalized Gauss-Bonnet theorem. Further topics. Prerequisite: Math 423.

428. Fields and Modules (3) spring
Field theory, including an introduction to Galois theory; the theory of modules, including tensor products and classical algebras. Prerequisite: Math 327.

430. Numerical Analysis (3) spring
Multistep methods for ordinary differential equations; finite difference methods for partial differential equations; numerical approximation of functions. Use of computer required. Prerequisite: Math 230 or consent of the department chairman.

431. Calculus of Variations (3)
Existence of a relative minimum for single and multiple integral problems; variational inequalities of elliptic and parabolic types and methods of approximating a solution. Prerequisite: Math 220 or its equivalent.

435. Functional Analysis I (3) fall
Banach spaces and linear operators; separation and extension theorems; open mapping and uniform boundedness principles; weak topologies; local convexity and duality; Banach algebras; spectral theory of operators; and compact operators. Prerequisite: Math 401.

436. Functional Analysis II (3) spring
Continuation of Math 435. Topics such as distribution theory, nonlinear operators, fixed point theory and applications to classical analysis. Prerequisite: Math 435.

443. General Topology II (3)
Continuation of Math 307, with such topics as filters and nets, topological products, local compactness, paracompactness, metrizability, uniformity, function spaces, dimension theory. Prerequisite: Math 307.

444. Algebraic Topology (3)
Continuation of Math 308. Cohomology theory, products, duality. Prerequisite: Math 308.

445. Topics in Algebraic Topology (3)
Selected topics reflecting the interests of the professor and the students. Prerequisite: Math 444.

449. Topics in Algebra (3)
Intensive study of topics in algebra with emphasis on recent developments. Prerequisite: consent of the department chairman. May be repeated for credit with the consent of the department chairman.

450. Special Topics (3) fall-spring
Intensive study of some field of the mathematical sciences not covered in listed courses. Prerequisite: consent of the department chairman. May be repeated for credit with the consent of the department chairman.

453. Function Theory (3)
The development of one or more topics in function theory, such as analytic continuation, maximum modulus principle, conformal representation, Taylor series analysis, integral functions, Dirichlet series, functions of several complex variables. Prerequisite: Math 416.

455. Topics in Number Theory (3)
Selected topics in algebraic and analytic number theory. Prerequisites: Math 316 and Math 327. May be repeated for credit with consent of the department chairman.

461. Topics in Mathematical Statistics (3)
An intensive study of one or more topics such as theory of statistical tests, statistical estimation, regression, analysis of variance, nonparametric methods, stochastic approximation, and decision theory. Prerequisites: Math 334 and Math 401. May be repeated for credit with consent of the department chairman.

463. Probability Theory (3)
Measure theoretic and analytic methods used in probability; measure theoretic foundations of probability; convergence of random variables; weak convergence of probability measures; characteristic functions; limit theorems; conditional expectation; martingales; and foundations of the therory of stochastic processes. Prerequisites: Math 309 and Math 401.

471. Homological Algebra (3)
Modules, tensor products, categories and functions, homology functors, projective and injective modules. Prerequisite: Math 428.

472. Group Representations (3)
Linear representations and character theory with emphasis on the finite and compact cases. Prerequisite: Math 428 or consent of the department chairman.

Mechanical Engineering and Mechanics

Professors. Fazil Erdogan, Ph.D. (Lehigh), *chairman;* Robert G. Sarubbi, Ph.D. (Lehigh), *assistant chairman;* Russell E. Benner, Ph.D. (Lehigh); Philip A. Blythe, Ph.D. (Manchester, England), *Center for the Application of Mathematics;* Forbes T. Brown, Sc.D. (M.I.T.); Dominic G. Edelen, Ph.D. (Johns Hopkins), *Center for the Application of Mathematics;* Ronald J. Hartranft, Ph.D. (Lehigh); Stanley H. Johnson, Ph.D. (Berkeley); Arturs Kalnins, Ph.D. (Michigan); Edward K. Levy, Sc.D. (M.I.T.), *director, Energy Research Center;* Alister K. Macpherson, Ph.D. (Sydney, Australia); Jerzy A. Owczarek, Ph.D. (London, England); Richard Roberts, Ph.D. (Lehigh); Donald O. Rockwell, Ph.D. (Lehigh); Kenneth N. Sawyers, Ph.D. (Brown); George C.M. Sih, Ph.D. (Lehigh), *director, Institute for Fracture and Solid Mechanics;* Charles R. Smith, Ph.D. (Stanford); Gerald F. Smith, Ph.D. (Brown), *Center for the Application of Mathematics;* Dean P. Updike, Ph.D. (Brown); Eric Varley, Ph.D. (Brown), *Center for the Application of Mathematics;* J. David A. Walker, Ph.D. (Western Ontario, Canada); Robert P. Wei, Ph.D. (Princeton).
Associate professors. Terry J. Delph, Ph.D. (Stanford); Gary D. Harlow, Ph.D. (Cornell); Jacob Y. Kazakia, Ph.D. (Lehigh), *Center for the Application of Mathematics;* Robert A. Lucas, Ph.D. (Lehigh); Sudhakar Neti, Ph.D. (Kentucky); John B. Ochs, Ph.D. (Penn State); N. Duke Perreira, Ph.D, (California, Los Angeles); Theodore A. Terry, Ph.D. (Lehigh); Arkady Voloshin, Ph.D. (Tel-Aviv, Israel).
Assistant professors. Bruce T. Murray, Ph.D. (Arizona); Tulga M. Ozsoy, Ph.D.; Kyra D. Stephanoff, D.Phil. (Oxford).
Adjunct professors. Stanley J. Jakubowski, B.S. (Lehigh); Mustafa R. Ozgu, Ph.D. (Lehigh).

Engineering is a creative profession aimed at satisfying needs of society through the combination of material, human and economic resources. Mechanical engineering is one of the broadest of the engineering professions, dealing generally with systems for energy conversion, material transport, and the control of motions and forces.

Mechanical engineers may choose from among many different activities in their careers, according to their interests and the changing needs of society. Some concentrate on the conversion of thermal, nuclear, solar, chemical and electrical energy, or on the problems of air, water, and noise pollution. Some concentrate on the design of mechanical systems used in transportation, production or health care, or by individual consumers. Some will be working, a decade from now, in fields that do not yet exist. Most will be engaged with concepts involving all four dimensions, space and time.

The curriculum leading toward the bachelor of science in mechanical engineering combines a broad base in mathematics, physical sciences, and the engineering sciences (mechanics of solids, materials, dynamics and fluid, thermal and electrical sciences) with exposure to laboratory, the design process, computer-aided analysis and design, and specific applications fields. Much of the latter occurs in four or more courses elected toward the end of the program from a variety of offerings, which are identified by 300-level course designations. Courses in mechanical engineering and mechanics are equally available.

A program also is offered leading toward the bachelor of science in engineering mechanics. This program requires additional courses in mathematics, solid mechanics and dynamics, and less required emphasis on thermodynamics. It is especially appropriate for those most interested in the analysis of the behavior of engineering structures.

Graduates in either degree are equipped for work in engineering or research and development, and in government service or industry. Those with ability and interest have suitable backgrounds for further studies at the graduate level.

Because of the flexibility of the curriculum, candidates for either degree may combine the study of mechanical engineering or engineering mechanics with that of other fields, such as industrial engineering, chemical engineering, materials engineering, and biology, into interdisciplinary programs that will prepare them for further work in the areas of manufacturing, nuclear engineering, energy conversion and conservation, environmental engineering, materials engineering, or biomechanics.

Undergraduates become thoroughly familiar with Lehigh's computer-aided design (CAD) laboratory. The lab is considered a *teaching* facility and the technology is regarded as an engineering tool that can be applied to solving a wide variety of problems. Undergraduates not only use CAD in their coursework but some have developed interactive tutorials that help fellow students expand on and clarify material presented in class.

freshman year (see page 36)

sophomore year, first semester (16 credit hours)

Math 23	Analytic Geometry and Calculus III (4)
Mech 1	Statics (3)
Phys 21, 22	Introductory Physics II and Laboratory (5)
ME 10	Graphics for Engineering Design (4)

sophomore year, second semester (17 credit hours)

Math 205	Linear Methods (3)
ME 104	Thermodynamics I (3)
Mech 11	Mechanics of Materials (3)
ME 21	Mechanical Engineering Laboratory I (1)
Mat 63	Engineering Materials and Processes (3)
Eco 1	Economics (4)

junior year, first semester (17 credit hours)

Mech 102	Dynamics (3)
ME 105	Thermodynamics II (3) or approved elective (3)
ME 231	Fluid Mechanics (3)
ECE 81	Principles of Electrical Engineering (4)
ME 121	Mechanical Engineering Laboratory II (1)
	general studies requirement (3)

junior year, second semester (18 credits)

ME 101	Mechanical Engineering Design I (2)
ME 151	Mechanical Elements (3)
Mech 203	Advanced Strength of Materials (3)
ECE 162	Electrical Laboratory (1)
ME 242	Mechanical Vibrations (3)
Math 208	Complex Variables (3) or
Math 231	Probability and Statistics (3)
	general studies requirement (3)

senior year, first semester (16 credit hours)

ME 108	Mechanical Engineering Laboratory III (2)
ME 102	Mechanical Engineering Design II (2)
ME 321	Introduction to Heat Transfer (3)
	approved elective (3)
	general studies requirement (3)
	elective (3)*

senior year, second semester (17 credit hours)

ME 109	Mechanical Engineering Laboratory IV (2)
	approved electives (9)
	general studies requirement (3)
	elective (3)*

*Please refer to description of normal program, page 37.

Note: In the junior year, candidates for the bachelor of science in mechanical engineering must take ME 105; candidates for the bachelor of science in engineering mechanics take Math 208.

Twelve credits of *approved electives* must be taken according to the following distribution.

At least one course (3 credits) from the following list of *engineering science electives*:

ME 322	Gas Dynamics (3)
ME 331	Advanced Fluid Mechanics (3)
ME 343	Control Systems (3)
Mech 302	Advanced Dynamics (3)
Mech 305	Advanced Mechanics of Materials (3)

At least two courses (6 credits) from the following list of elective courses having *design or manufacturing content* with no more than one course (3 credits) being from outside Mechanical Engineering:

ME 310	Projects (3)
ME 312	Synthesis of Mechanisms (3)
ME 323	Reciprocating and Centrifugal Engines (3)
ME 327	Coal Combustion and Conversion (3)
ME 329	Solar Energy Conversion (3)
ME 340	Advanced Mechanical Design (3)
ME 341	Mechanical Systems (3)
ME 342	Dynamics of Engineering Systems (3)
ME 345	Fluid Power (3)
ME 348	Computer-Aided Design (3)
ME 360	Nuclear Reactor Engineering (3)

Any design or manufacturing course taken outside of Mechanical Engineering must be approved by the student's advisor.

Other approved elective courses in the Mechanical Engineering and Mechanics Department are:

ME 320	Thermodynamics III (3)
Mech 307	Mechanics of Continua (3)
Mech 312	Finite Element Analysis (3)
Mech 313	Fracture Mechanics (3)
Mech 323	Fluid Mechanics of Ocean and Atmosphere (3)
Mech 326	Aerodynamics (3)

For candidates for the bachelor of science in engineering mechanics, the following courses are required: Mech 302, Advanced Dynamics; Mech 305, Advanced Mechanics of Materials; Mech 307, Mechanics of Continua; and Math 322, Methods of Applied Analysis I.

Undergraduate Courses in Mechanical Engineering

ME 10. Graphics for Engineering Design (4) fall
Engineering graphics, elements of descriptive geometry, and geometric aspects of design including their interaction with manufacturing. Emphasis on computer graphics and computer-aided design and manufacturing (CAD/CAM) methods.

ME 21. Mechanical Engineering Laboratory I (1) fall, spring
Laboratory methods employed in mechanical engineering and mechanics. Planning and execution of experiments, analysis of data, and writing of reports. Introduction to elementary instrumentation. Prerequisite: Mech 11, previously or concurrently.

ME 101. Mechanical Engineering Design I (2) spring
Objectives and specifications are developed for design projects to be carried out in the following semester. Alternative design concepts are proposed and oral and written reports of feasibility studies are presented.

ME 102. Mechanical Engineering Design II (2) fall
A continuation of ME 101 in which groups are organized to do preliminary design on a previously defined project. Program organization techniques are used and laboratory testing and data acquisition are carried out as needed to promote design development. Prototypes are constructed and tested, when practical. Prerequisites: ME 101, Mech 11, and ME 104.

ME 104. Thermodynamics I (3) fall, spring
Basic concepts and principles of thermodynamics with emphasis on simple compressible substances. First and second law development, energy equations, reversibility, entropy and probability. Properties of pure substances and thermodynamic cycles. Prerequisites: Math 23 and Phys 11.

ME 105. Thermodynamics II (3) fall, spring
Equations of state, nonreacting and reacting mixtures, combustion, equilibrium of mixtures both reacting and nonreacting, statistical thermodynamics concepts. Prerequisite: ME 104.

ME 108. Mechanical Engineering Laboratory III (2) fall
Lectures and laboratory exercises relating to various phases of engineering laboratory technique and procedures. Includes planning, execution, and analysis of tests and writing of reports. Prerequisite: ME 105.

ME 109. Mechanical Engineering Laboratory IV (2) spring
Continuation of ME 108.

ME 110. Thesis (1-3) fall-spring
Candidates for the degree of bachelor of science in mechanical engineering may, with the approval of the director of the curriculum, undertake a thesis as a portion of the work during the senior year.

ME 121. Mechanical Engineering Laboratory II (1) fall, spring
A continuation of ME 21 including the use of transducers, advanced instrumentration, and data acquisition. Emphasis on the planning of experiments and interpretation of results. Prerequisites: ME 21 and ME 104.

ME 151. Mechanical Elements (3) fall, spring
Methods for the analysis and design of machine elements such as springs, gears, clutches, brakes, and bearings. Motion analysis of cams and selected mechanisms. Projects requiring the design of simple mechanisms of mechanical sub-assemblies. Prerequisites: Mech 11, ME 10 and Mech 102.

For Advanced Undergraduates and Graduate Students

ME 231. Fluid Mechanics (3) fall, spring
Fundamental concepts. Physical similarity. Kinematics of fluid flow. Equations of flow in integral form. Equations of flow of perfect fluids. Plane irrotational flow of incompressible fluids. Navier-Stokes equation: hydrodynamic stability; turbulence. Two-dimensional boundary layers in incompressible flows: separation of flow; wakes; drag. Effects of compressibility of fluid flow. Hydraulic treatment of losses in flows in ducts. Flows with free surface. Basic measurements techniques. Prerequisite: Math 205.

ME 242. Mechanical Vibrations (3) fall, spring
Physical modeling of vibrating systems. Linearization. Free and forced single and multiple degree of freedom systems. Simple continuous systems. Engineering applications. Prerequisites: Mech 11, Mech 102 or 103, Math 205.

ME 310. Projects (3) fall, spring
Project work on any aspect of engineering, performed either individually or as a member of a team made up of students, possibly from other disciplines. Direction of the projects may be provided by faculty from several departments and could include interaction with outside consultants and local communities and industries. Prerequisite: consent of the department chairperson.

ME 312. Synthesis of Mechanisms (3) fall
Geometry and constrained plane motion with application to linkage design. Type of number synthesis. Comparison of motion analysis by graphical, analytical and computer techniques. Euler-Savary and related curvature techniques as applied to cam, gear and linkage systems. Introduction to the analysis of space mechanisms. Prerequisites: Math 205, Mech 102. Terry

ME 320. Thermodynamics III (3) fall
Advanced treatment of thermodynamic laws both for single element and mixtures. Phase equilibrium. Ideal solutions, chemical equilibrium. Thermodynamic cycle analysis, real fluid properties, availability. Prerequisite: ME 104. Macpherson

ME 321. Introduction to Heat Transfer (3) fall, spring
Analytical, numerical, and analog solutions to steady and transient, one- and two-dimensional conduction problems; thermal radiation, free and forced convection of laminar and turbulent flows inside cylindrical tubes and over external surfaces; thermal design of heat. Prerequisites: ME 104, ME 231. Levy, Neti, Walker

ME 322. Gas Dynamics (3) spring
Equations of flow of compressible fluids. Thermodynamic properties of gases. Shock waves. One-dimensional steady flow through ducts with variable cross-sectional area, flows with viscous friction and heat addition. Prerequisites: ME 231, ME 104, Math 205. Owczarek, Rockwell

ME 323. Reciprocating and Centrifugal Engines (3) fall
Thermal analysis and design of internal combustion engines (conventional and unconventional), gas turbine engines, air breathing jet engines, and rockets. Components such as jet nozzles, compressors, turbines, and combustion chambers are chosen to exemplify the theory and development of different types of components. Both ideal fluid and real fluid approaches are considered. Prerequisite: ME 105.

ME 327. Coal Combustion and Conversion (3) fall
Application of the thermal-fluid sciences in the analysis and critical assessment of coal combustion and conversion processes. Properties of coal; environmental constraints; precombustion cleaning; fluidized bed combustion; flue gas desulfurization; gasification; liquefaction; power cycle analysis; energy economics. Prerequisite: ME 105 or senior standing. Levy

ME 329. Solar Energy Conversion (3) fall
Modeling of flat plate, concentrating, imaging and non-imaging collectors. Estimation of available solar energy. Physics of solar cells. Storage systems. Solar heating design. Engineering economics as applied to solar system design. Passive system analysis and design. Prerequisite: a first course in thermodynamics. Neti, Sarubbi

ME 331. Advanced Fluid Mechanics (3) fall
Kinematics of fluid flow. Conservation equations for inviscid and viscous flows; integral forms of equations. Two-dimensional potential flow theory of incompressible fluids with applications. Boundary layers. Introduction to free shear layer and boundary layer stability and structure of turbulence. Transition from laminar to turbulent boundary layers. Separation of flow. Steady and unsteady stall. Secondary flows. Flow of non-Newtonian fluids. Hydrodynamic lubrication. Measurement techniques. Prerequisite: ME 231 or equivalent. Owczarek, Rockwell, C. Smith

ME 340. Advanced Mechanical Design (3) fall
Probabilistic design of mechanical components and systems. Reliability functions, hazard models and product life prediction. Theoretical stress-strength-time models. Static and dynamic reliability models. Optimum design of mechanical systems for reliability objectives or constraints. Prerequisite: Math 231. Benner

ME 341. Mechanical Systems (3) spring
Advanced topics in mechanical systems design. Friction, wear and lubrication with applications of friction drives, journal and rolling-element bearings. Shock and vibration control in machine elements such as springs, gears and rotating discs. Rotor-bearing system dynamics. Balancing of rotating and reciprocating machines. Prerequisites: ME 151, Mech 203 and ME 242. Benner

ME 342. Dynamics of Engineering Systems (3) spring
Dynamic analysis of mechanical, electromechanical, fluid and thermal engineering systems with emphasis on the modeling process. Survey of numerical methods with emphasis on dynamic simulation and computer practice. Prerequisite: ME 242. Johnson

ME 343. Control Systems (3) fall
Linear analysis of mechanical, hydraulic, pneumatic, thermal and electrical feedback control systems. Transient and frequency response, root locus, stability criteria and compensation techniques. Prerequisite: ME 242. Brown, Johnson

ME 345. Fluid Power (3) fall
Design, modeling and static and dynamic analyses of fluid power pumps, motors, valves, lines and systems, with emphasis on developing a fundamental understanding of industrial and mobile hydraulics and hydraulic servosystems. Laboratory demonstrations and experiments. Prerequisites: ME 231, ME 242. Brown

ME 348. Computer-Aided Design (3) spring
Impact of computer graphics technology on mechanical design and manufacturing. Geometric modeling including wireframe modeling, solids modeling, computer graphics and CAD/CAM systems. Analysis techniques for mass properties, kinematics and the use of finite elements for distributed properties. Design for manufacturability and automated assembly. Prerequisites: ME 12, ME 151, ME 242. Ochs, Lucas

ME 350. Special Topics (1-4)
A study of some field of mechanical engineering not covered elsewhere. Prerequisite: consent of the department chairperson.

ME 360. (ChE 360) Nuclear Reactor Engineering (3) spring
A consideration of the engineering problems in nuclear reactor design and operation. Topics include reactor fuels and materials, thermal aspects, instrumentation and control problems, radiation protection and shielding, fuel processing, and reactor design. Prerequisite: senior standing in engineering or physical science. Clump, Neti

ME 387. (ChE 387, ECE 387) Digital Control (3) spring
Sampled-data systems; z-transforms; pulse transfer functions; stability in the z-plane; root locus and frequency response design methods; minimal prototype design; digital control hardware; discrete state variables; state transition matrix; Liapunov stability state feedback control. (2 lectures and one laboratory per week). Prerequisite: ChE 386 or ECE 212 or ME 342 or consent of instructor. Luyben

Graduate Programs in Mechanical Engineering

The department offers programs of study leading to the degrees of master of science, master of engineering, and doctor of philosophy in mechanical engineering.

A student whose background is different from that required in the undergraduate mechanical engineering curriculum or who has a particular deficiency may be required to present a larger number of credits than the minimum indicated for graduation.

Subject to approval, courses from other engineering curricula, such as mechanics, chemical engineering, and metallurgy and materials engineering, may be included in the major.

A student who plans to work for the doctorate should submit a general plan to the department chairperson during the first year and arrange for the qualifying examinations.

Master of Science

The M.S. is often considered the appropriate background for the person who wants to work on the more technical creative aspects of mechanical engineering. As such it emphasizes a broad extension of fundamentals rather than specialization in one field, although there is considerable latitude in the choice of courses. The required six-credit-hour thesis for the M.S. likely concentrates in one research area, but can be viewed primarily as an in-depth project experience under the guidance of an expert.

Master of Engineering

The program leading to the M. Eng. aims primarily at advanced design methods and creative design projects. Six credit hours of ME 460, Engineering Project, are required in lieu of a thesis. A wide range of interdisciplinary course offerings permits construction of a program including several of the following areas: mechanical systems, reliability engineering, probabilistic approaches to design, mechanism synthesis, stress analysis, digital and analog computer-aided design, and optimum design.

Doctor of Philosophy

Candidacy for the Ph.D. follows passage of a qualifying examination that also emphasizes a broad grasp of fundamentals. In most cases, largely through the dissertation, the candidate emphasizes one or more specialized fields and engages in extensive research in collaboration with one or more faculty members. Basic and applied research is ongoing in a variety of fields including fluid and solid mechanics, heat and mass transfer, thermodynamics, energy conversion, mechanical design and system dynamics and control.

Equipment available for research includes mini- and micro-computers with A/D converters, high-speed TV and photographic system, several channels of hot wire/film anemometry, a six-inch interferometer, a two-phase boiling loop, several water and wind tunnels, fluidized bed test facilities, a fluidized combustor, gas-dynamic test facilities, a corrosion fatigue test facility, a variety of electrodynamics and servo-controlled hydraulic testing machines, a 1200-pound shaker table, a photo-elastic bench, lasers, and fluid power test stands. The Computer-Aided Design (CAD) Laboratory includes a DEC VAX 11/780 mini-computer that drives six McAuto Unigraphics stations, six DEC VS11 color dynamic terminals and five VT100 terminals. Commercial software is available for design, testing, analysis and solids modeling.

Some of the recent research activities of the staff are listed below.

Thermofluids. Structure of turbulent boundary layers, wakes and jets; drag reduction in turbulent flows; acoustic-flow interactions; attenuation of aerodynamic noise; flows in radial compressors; vortex-solid boundary interactions, flow in gas centrifuges; unsteady viscous flows; viscous effects in turbomachinery; rotating fluidized beds; fluidized bed combustion; instrumentation for liquid film dynamics; inverse annular two-phase flows; laminarturbulent transaction behind a barrier; self-sustained oscillations of separated flows; flow-induced vibrations; fluid transients in tubes; Laser-Doppler velocimetry; fluidized-bed heat exchangers; multi-component boiling; convection in postcritical heat-flux boiling; thermal hydraulics of liquid metal boiling; Raman spectra applied to temperatures in two-phase flow; measurements in gas flows following shock waves; optimization of designs of air separation plants; cycle analysis for fluidized-bed combustors; cycle analysis applied to coal gasifiers and powercycles; breeder-reactor safety; light-water reactor safety; control optimization of heat pumps; finite element computations relative to turbulent flows; flutter of blades in axial-flow turbomachinery.

System dynamics and control. Modeling and advanced simulation of dynamic systems including vehicles, chemical processes, aero-elastic structures and heat-pump systems; methods of experimental identification and analysis of distributed-parameter systems including unsteady turbulent flow in tubes and diffusers; energy methods and bondgraphs in modeling; stochastic optimal control techniques applied to stable platforms for overland vehicles; conceptualization and hardware development of innovative components and systems for fluid power control; application of robots to manufacturing; computer-controlled theatre lighting design.

Graduate courses are generally offered every third semester.

ME 411. Boundary-Layer Theory (3) fall
The course is intended as a first graduate course in viscous flow. An introduction to boundary-layer theory, thermodynamics and heat transfer at the undergraduate level are assumed to have been completed. Topics include the fundamental equation of continuum fluid mechanics, the concept of asymptotic methods and low and high Reynolds number flows, laminar boundary layers, generalized similarity methods, two- and three-dimensional flows, steady and unsteady flows and an introduction to hydrodynamic stability. The material is covered in the context of providing a logical basis as an introduction to a further course in turbulent flows. Walker

ME 413. Numerical Methods in Mechanical Engineering (3)
Zeros of functions, difference tables, interpolation, integration, differentiation. Divided differences, numerical solution of ordinary differential equations of the boundary and initial value type. Eigen problems. Curve fitting, matrix manipulation and solution of linear algebraic equations. Partial differential equations of the hyperbolic, elliptic and parabolic type. Application to problems in mechanical engineering. Walker

ME 415. Flow-Induced Vibration (3)
Excitation of streamlined- and bluff-bodies by self-flutter, vortex, turbulence, and gust-excitation mechanisms. Analogous excitation of fluid (compressible- and free-surface) systems having rigid boundaries. Extensive case studies. Rockwell

ME 420. Advanced Thermodynamics (3) spring
Critical review of thermodynamics systems. Criteria for equilibrium. Applications to electromagnetic systems. Statistical thermodynamics. Irreversible thermodynamics. Thermoelectric phenomena. Macpherson

ME 421. Topics of Thermodynamics (3)
Emphasis on theoretical and experimental treatment of combustion processes including dissociation, flame temperature calculations, diffusion flames, stability and propagation; related problems in compressible flow involving one-dimensional, oblique shock waves and detonation waves. Methods of measurement and instrumentation.

ME 424. Turbulent Flow (3) fall
Stability of laminar flow; transition to turbulence. Navier-Stokes equations with turbulence. Bounded turbulent shear flows; free shear flows; statistical description of turbulence. Prerequisite: ME 331. Rockwell

ME 426. Radiative and Conductive Heat Transfer (3) spring
Principles of radiative transfer; thermal-radiative properties of diffuse and specular surfaces; radiative exchange between bodies; radiative transport through absorbing, emitting and scattering media. Advanced topics in steady-state and transient conduction; analytical and numberical solutions; problems of combined conductive and radiative heat transfer. Prerequisite: ME 321 or ChE 421.

ME 427. (ChE 427) Multiphase Heat Transfer (3)
Heat transfer and fluid dynamics of multiphase systems. Subcooled, nucleate, and film boiling; bubble nucleation;

dynamics of bubble growth and collapse; vapor-liquid cocurrent flow regimes; two-phase pressure drop and momentum exchange, low instabilities; convective-flow boiling; simultaneous heat and mass transfer. Prerequisite: ME 321 or ChE 421.

ME 428. Boundary Layers and Convective Heat Transfer (3) spring
Navier-Stokes and energy equations, laminar boundary layer theory, analysis of friction drag, transfer and separation. Transition from laminar to turbulent flow. Turbulent boundary layer theory.Prandtl mixing length, turbulent friction drag, and heat transfer. Integral methods. Flow in ducts, wakes and jets. Natural convection heat transfer. Prerequisite: ME 331 or ME 321. Levy, Owczarek, Rockwell

ME 431. Advanced Gas Dynamics (3)
Methods of characteristics. Unsteady continuous flow. Unsteady flows with discontinuities. Shock tubes. Detonation waves. Two-dimensional and axisymmetric supersonic flows. Momentum and energy equation of compressible viscous fluids. Prerequisite: ME 322. Owczarek, Rockwell

ME 432. Topics in Gas Dynamics (3)
The equilibrium thermodynamic properties of a dissociating mixture of gases. Equilibrium flow of dissociating gases. Vibrational and chemical nonequilibrium. Criteria for thermodynamic equilibrium of gas flow. Chemical kinetics of gaseous reactions. Equations of flow of a reacting gas mixture. Nonequilibrium flows. Application to design of ram-jets and rocket nozzles and of reentry vehicles. Prerequisite: ME 320 and ME 322.

ME 433. (ChE 433, ECE 433) State Space Control (3) fall
State-space methods of feedback control system design and design optimization for invariant and time-varying deterministic, continuous systems; pole positioning, observability, controllability, modal control, observer design, the theory of optimal processes and Pontryagin's Maximum Principle, the linear quadratic optimal regulator problem, Lyapunov functions and stability theorems, linear optimal openloop control; introduction to the calculus of variations; introduction to the control of distributed parameter systems. Intended for engineers with a variety of backgrounds. Examples will be drawn from mechanical, electrical and chemical engineering applications. Prerequisite: ME 343 or ECE 212 or ChE 386 or consent of instructor. Johnson, Georgakis

ME 434. (ChE 434, ECE 434) Multivariable Process Control (3)
A state-of-the-art review of multivariable methods of interest to process control applications. Design techniques examined include loop interaction analysis, frequency domain methods (Inverse Nyquist Array, Characteristic Loci and Singular Value Decomposition) feedforward control, internal model control and dynamic matrix control. Special attention is placed on the interaction of process design and process control. Most of the above methods are used to compare the relative performance of intensive and extensive variable control structures. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Georgakis

ME 436. (ChE 436, ECE 436) Systems Identification (3)
The determination of model parameters from time-history and frequency response data by graphical, deterministic and stochastic methods. Examples and exercises taken from process industries, communications and aerospace testing. Regression, quasilinearization and invariant-imbedding techniques for nonlinear system parameter identification included. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor. Johnson

ME 437. (ChE 437, ECE 437) Stochastic Control (3) spring
Linear and nonlinear models for stochastic systems. Controllability and observability. Minimum variance state estimation. Linear quadratic Gausian control problem. Computational considerations. Nonlinear control problem in stochastic systems. Prerequisite: ChE 433 or ME 433 or ECE 433 or consent of instructor.

ME 439. Fluid Mechanics of Turbo-machinery (3) spring
The Euler equation. One-dimensional analysis of turbomachinery. Performance characteristics. Limitations on performance imposed by real fluid effects. Cascade flow. Two- and three- dimensional flow. Surge and stall. Owczarek

ME 442. Analytical Methods in Engineering I (3) fall
Analytical methods of solution for discrete and continuous engineering systems. Theoretical, numerical and approximate methods of solution applied to equilibrium, characteristic value and propagation types of engineering problems. Lucas, Walker, Erdogan, Sawyers

ME 443. Analytical Methods in Engineering II (3) spring
Continuation of ME 442.

ME 444. Experimental Stress Analysis in Design (3)
Fundamental concepts of strain measurements and application of strain gages and strain gage circuits. Two- and three-dimensional photoelasticity, stress separation techniques, birefringent coating Moire methods, caustics. Use of image analysis in data acquisition and interpretation. Selected laboratory experiments. Roberts, Wei, Voloshin

ME 446. Mechanical Reliability (3)
Design of mechanical engineering systems to reliability specifications. Probabilistic failure models for mechanical components. Methods for the analysis and improvement of system reliability. Effect of component tolerance and parameter variation on system failure. Reliability testing. Prerequisite: Math 231 or Math 309. Benner

ME 450. Special Topics (3)
An intensive study of some field of mechanical engineering not covered in more general courses.

ME 451. Seminar (1-3)
Critical discussion of recent advances in mechanical engineering.

ME 458. Modeling of Dynamic Systems (3) spring
Modeling of complex linear and nonlinear energetic dynamic engineering systems. Emphasis on subdivision into multiport elements and representation by the bondgraph language using direct, energetic, and experimental methods. Field lumping. Analytical and graphical reductions. Analog, digital and hybrid simulation. Examples including mechanisms, electromechanical transducers, electric and fluid circuits, and thermal systems. Prerequisite: ME 342 or ME 343 or ECE 212. Brown, Johnson

ME 460. Engineering Project (1-6)
Project work on some aspect of mechanical engineering in an area of student and faculty interest. Selection and direction of the project could involve interaction with local communities or industries. Prerequisite: consent of the department chairperson.

Undergraduate Courses in Mechanics

Mech 1. Statics (3) fall-spring
Composition and resolution of forces; equivalent force systems; equilibrium of particles and rigid bodies; centroids and centers of gravity; analysis of simple structures; internal forces in beams; friction; moments and products of inertia; methods of virtual work. Prerequisites: Math 22 and Phys 11.

Mech 11. Mechanics of Materials (3)
Strength and elasticity of materials; theory of stresses and strains; deflection of beams and shafts; torsion; buckling of struts. Prerequisites: Mech 1, Math 23, previously or concurrently.

Mech 102. Dynamics (3) fall-spring
Kinematics and kinetics of particles and rigid bodies in two and three dimensions; relative motion; work and energy; impulse and momentum. Prerequisites: Mech 1 and Math 23.

Mech 103. Principles of Mechanics (4)
Composition and resolution of forces; equivalent force systems; equilibrium of particles and rigid bodies; friction. Kinematics and kinetics of particles and rigid bodies; relative motion; work and energy; impulse and momentum. Prerequisites: Math 23 and Phys 11.

For Advanced Undergraduates and Graduate Students

Mech 203. Advanced Strength of Materials (3) fall-spring
Elementary consideration of stress and strain at a point. Stress strain relation in two dimensions. Basic equations of motion. Classical therories of failures. Analysis of simple continuum systems with applications to materials behavior phenomena. Prerequisites: Mech 11 and Math 205.

Mech 302. Advanced Dynamics (3) spring
Fundamental dynamic theorems and their application to the study of the motion of particles and rigid bodies, with particular emphasis on three-dimensional motion. Use of generalized cordinates; Lagrange's equations and their applications. Prerequisites: Mech 102 or 103; Math 205. Sarubbi, Johnson

Mech 305. Advanced Mechanics of Materials (3) fall
Selected problems of stress and strain that are governed by ordinary differential equations such as combined bending and torsion of bars, curved bars, beams and elastic foundation. Membrane analogy. Principles of indeterminate analysis. Energy methods. Prerequisites: Mech 203 or equivalent; Math 205.

Mech 307. Mechanics of Continua (3) spring
Fundamental principles of the mechanics of deformable bodies. Study of stress, velocity and acceleration fields. Compatibility equations, conservation laws. Applications to two-dimensional problems in the theories of perfectly elastic materials and also perfectly plastic materials. Prerequisites: Mech 203 and 305. G. Smith

Mech 312. Finite Element Analysis (3) spring
Basic concepts for representing distributed-parameter media with complicated boundaries by a system of small elements. Emphasis on elastic media. Element stiffness matrices based on assumed displacements. Isoparametric elements. Assembly of global stiffness matrix. Applications to plane elasticity, solids of revolution, bending of plates, shells, vibration, and heat transfer. Students use prewritten Fortran subroutines to produce their own finite element program. Prerequisites: Mech 11 and Math 205. Kalnins

Mech 313. Fracture Mechanics (3) spring
Fracture behavior in solids, the Griffith theory and extensions to linear elastic fracture process models; stress analysis of cracks; generalization of fracture criteria; plasticity; subcritical crack growth, including environmental and thermal effects; fracture toughness testing; failure analysis and fracture control plans. Prerequisites: Mech 11 and Math 205. Roberts, Sih, Wei

Mech 323. (CE 324) Fluid Mechanics of Ocean and Atmosphere (3) fall
Hydrostatics of the ocean and atmosphere. Vertical stability. Fluid motion in a rotating cordinate system. Geostrophic flow; ocean currents; surface and internal waves. Prerequisite: ME 231 or CE 121. Macpherson

Mech 326. Aerodynamics (3) spring
Application of fluid dynamics to external flows. Simple exact solutions in two dimensions. Kutta condition at a trailing edge. Thin aerofoil theory, steady and unsteady flow. Lifting line theory. Flow past slender bodies. Linearized compressible flow. Far field solutions, shock formation. Prerequisites: ME 231 and Math 208. Blythe

Mech 350. Special Topics (3)
A study of some field of engineering mechanics not covered elsewhere. Prerequisite: consent of the department chairperson.

Graduate Program in Mechanics

The graduate courses in mechanics are open in general to students who have been graduated from a curriculum in engineering mechanics, engineering mathematics, engineering physics, civil engineering, or mechanical engineering at a recognized institution.

A candidate for the M.S. in applied mechanics is expected to possess a thorough knowledge of undergraduate mathematics and mechanics. Math 205, 208 and 322, and Mech 302 and 305, or their equivalents, are considered prerequisites for graduate work in applied mechanics. Any of these courses that have not been taken by the student as an undergraduate should be included in the graduate program. The student may then be required to present a larger number of credits than the minimum required for graduation. A thesis carrying six credit hours is required of all M.S. candidates.

Current departmental research activities of interest include programs as follows:

Continuum mechanics. Formulation of field equations and constitutive equations in non-linear elasticity theories. Mechanics of viscoelastic solids and fluids Plasticity theory. Generalized continuum mechanics. Thermomechanical and electro-mechanical interactions. Stress birefringence. Wave propagation. Finite amplitude wave propagation.

Fracture mechanics. Stress analysis of media containing inclusions or perforations, including viscoelastic, non-homogeneous, and anisotropic materials. Analysis of crack growth under static, periodic, and random loadings and environmental effects. Optimizations of fracture control. Crack propagation theories for nonlinear materials. Influence of cracks on the strength of structural members.

Stochastic processes. Modeling of random behavior in mechanical systems. Static and time-dependent stochastic fracture mechanics.

Thin shell analysis. Free vibration and dynamics response of elastic shells. Elastic-plastic deformations of shells upon cyclic thermal loadings. Applications of shell analysis to nuclear power plant components (pressure vessels, curved pipes), and to biological systems (eye, frog's eggs and other cells).

Theoretical fluid mechanics. Vortex boundary layer interaction, modelling of turbulent boundary layers; geophysical flows such as frontal systems and mountain flows; statistical mechanics of plasmas, liquids and shock waves; finite amplitude waves in stratified gases and liquids; shock wave propagation; non-Newtonian flows in flexible tubes with application to hemorheology; magneto-fluid mechanics; wing theory; thermally driven flows.

Special departmental facilities of interest to the graduate student include the latest mechanical, electrodynamic and servocontrolled hydraulic testing machines, photoelastic bench, laser, and corrosion fatigue test facilities.

Graduate courses are generally offered every third semester.

Mech 402. Advanced Analytical Mechanics (3) fall
Fundamental dynamical theorems and their applications to advanced problems; generalized coordinate; Lagrange's equations; fixed and moving constraints; nonholonomic systems; Hamilton's principle; Hamilton's canonical equations; contact transformations; Hamilton-Jacobi partial differential equation. Prerequisite: Mech 302 or consent of the department chairperson. Johnson, Sarubbi

Mech 405. Response of Systems to Random Loads (3) fall
Stochastic processes; correlation functions and power spectra;

response of mechanical systems to one-dimensional and multidimensional random load fields; probability of the random vibrations of mechanical systems; applications to failure prediction. Prerequisite: consent of the department chairperson. Harlow, Sarubbi

Mech 406. Advanced Dynamics and Vibrations (3) fall
Kinematical and mathematical preliminaries, basic notions of variational calculus; Hamilton's principle. Lagrange equations, discrete systems; dynamics of continuous systems. Sturm-Liouville theory, eigenvalue problems; transient and frequency response. There will be frequent examples of the application of these techniques to the analysis of shafts, beams, membranes, and plates. Prerequisites: ME 242 and Mech 302. Erdogan, S. Johnson

Mech 407. Wave Propagation in Solids (3) fall
Wave propagation in deformable elastic solids; problems in half-space and layered media; application of integral transformations. Erdogan, Delph

Mech 409. Theory of Elasticity II (3) fall
Kinematics of deformation, analysis of stress, stress-strain relations, strain energy function. Reciprocal theorem. Methods for two-dimensional boundary value problems applied to anti-plane, torsion, bending and plane problems.Approximate and numerical methods of solution. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of material. Erdogan, Hartranft, Sih

Mech 410. Theory of Elasticity II (3) spring
Advanced topics in the theory of elasticity. The subject matter may vary from year to year and may include, e.g., theory of potential functions, linear thermoelasticity, dynamics of deformable media, integral transforms and complex-variable methods in classical elasticity. Problems of boundary layer type in elasticity; current developments on the micro-structure theory of elasticity. Prerequisites: Mech 409, Math 208, or consent of the department chairperson.

Mech 411. (Phys 471) Continuum Mechanics (3)
An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of the theories to specific problems are given. G. Smith

Mech 412. Theory of Plasticity (3)
Time-independent mechanical behavior in simple tension, compression and torsion. Time-independent stress-strain relations for materials under combined stress. Application to problems with axisymmetric stress distributions. Loading, unloading, residual stresses, shakedown. Limit theorems of perfectly plastic bodies; applications. The slip line field for plane strain; examples. Plastic analysis of structures; frames, plates, shells. Finite element approach to problems. Time-dependent mechanical behavior of materials, creep. Prerequisites: Math 205; Mech 305 or equivalent course in advanced mechanics of materials. Kalnins, Updike

Mech 413. Fracture Mechanics (3)
Introduction to fracture mechanics criteria for bodies containing cracks and notches; microscopic and macroscopic analytical modeling; fracture toughness concept; test specimens; stress intensity factor evaluation of crack systems; prediction of crack trajectory and direction of initiation; dynamic loading and crack propagation; fatigue crack growth and environmental effects; brittle-ductile transition phenomenon in metals; visco-elastic behavior of polymers. Prerequisites: Mech 203, Math 208, or consent of the department chairperson. Erdogan, Sih, Wei

Mech 414. Viscoelasticity and Creep (3)
Mechanical models for linear viscoelastic materials, representations by differential operators and hereditary integrals, creep and relaxation functions, correspondence principle, quasi-static analysis, wave propagation, nonlinear material behavior, uniaxial creep laws, multiaxial generalizations, creep damage and failure. Prerequisite: Mech 409. Delph

Mech 415. (CE 468) Stability of Elastic Structures (3)
Basic concepts of instability of a structure; bifurcation, energy increment, snap-through, dynamic instability. Analytical and numerical methods of finding buckling loads of columns. Postbuckling deformations of cantilevel column. Dynamic buckling with nonconservative forces. Effects of initial imperfections. Inelastic buckling. Buckling by torsion and flexure. Variational methods. Buckling of frames. Instability problems of thin plates and shells. Prerequisite: Math 205. Kalnins

Mech 416. (CE 464) Analysis of Plates and Shells (3) fall
Bending of rectangular and circular plates, plates under lateral loads, plates with thermal and inelastic strains, effect of inplane forces, large deflections, buckling of plates. Geometry and governing equations of shell, shells of revolution, membrane states, edge solutions, solution by numerical integration, non-symmetric problems, buckling of shells, applications to pressure vessels. Prerequisites: Math; Mech 305, or equivalent course in advanced mechanics of materials. Kalnins, Updike

Mech 417. Mixed Boundary Value Problems in Mechanics (3)
General description of mixed boundary value problems in potential theory and solid mechanics. Solutions by dual series, dual integral equations and singular integral equations. Approximate and numerical methods. Erdogan

Mech 418. Finite Element Methods (3) fall
Finite element approximations to the solutions of differential equations of engineering interest are developed from variational principles or by Galerkin's method. Linear and nonlinear example from heat transfer, solid mechanics, and fluid mechanics are used to illustrate applications of the method. The course emphasizes the development of computer programs to carry out the required calculations. Prerequisite: knowledge of FORTRAN. Delph

Mech 419. (ChE 419) Asymptotic Methods in the Engineering Sciences (3)
Introductory level course with emphasis on practical applications. Material covered includes: Asymptotic expansions. Regular and singular perturbations; asymptotic matching. Boundary value problems; distinguished limits. Multiple scale expansion. W.K.B. Theory. Far field theories. Blythe

Mech 421. Fluid Mechanics (3)
Kinematics of fluid flow. Lagrangian and Eulerian descriptions. Basic conservation laws. Review of thermodynamics. Constitutive relations. Vorticity, circulation. Irrotational flow. Bernoulli theorems. Vortex motion, velocity motion, velocity potential, stream function. Potential flow in two and three dimensions. Compressible flow; sound waves, simple waves; gas dynamic discontinuities. Salathe

Mech 422. Fluid Mechanics (3)
Similarity and dimensional analysis. Exact solution for viscous incompressible flow. Singular perturbation theory, with application to flows at low and high Reynolds number. Hydrodynamic stability. Depending on interest, additional topics from Magnetohydrodynamics, kinetic theory, wing theory, turbulence, water waves, flows in flexible tubes. Prerequisite: Mech 421. Salathe

Mech 424. Unsteady Fluid Flows (3)
Gas dynamics, finite amplitude disturbances in perfect and real gases; channel flows; three-dimensional acoustics; theories of the sonic boom. Motions in fluids with a free surface; basic hydrodynamics, small amplitude waves on deep water; ship waves; dispersive waves; shallow water gravity waves and atmospheric waves. Hemodynamics; pulsatile blood flow at high and low Reynolds number. Models of the interaction of flow with artery walls. Varley

Mech 437. (Mat 437) Dislocations and Strengths in Crystals (3)
Theory and application of dislocations. Geometrical interpretation; elastic properties; force on a dislocation; dislocation interactions and reactions; multiplication. Dislocations in crystal structures. Selected topics in strengthening plastic flow, creep, fatigue and fracture are discussed. Prerequisites: Math 205 or 221, or Met 320; Met 317, or consent of the department chairperson. Chou, Wei

Mech 450. Special Problems (3)
An intensive study of some field of applied mechanics not covered in more general courses.

Engineering Mathematics Courses

EMA 425. Variational Methods in Science and Engineering (3)
Variational problems with one independent variable; Euler-Lagrange equations; methods of solution; space and time dependent fields; null Lagrangians and inhomogeneous Dirichlet data; problems with constraints; symmetries and conservation laws; variational approximation methods, Rayleigh-Ritz, Galerkin, finite element, and collocation. Problems and examples will be drawn from the mechanics of solids, fluids, and related fields. Prerequisite: consent of chairman. Edelen

EMA 450. Special Topics (3)
An intensive study of some field of engineering mathematics not covered in other courses.

Military Science

Professor. Lt. Col. John F. Fravel, Jr., M.A. (Webster College), *chairperson.*
Assistant professors. Maj. William D. Archer, M.A. (South Carolina); Capt. Peter A. Carozza, B.A. (Gettysburg); Capt. Lawrence A. Deren, B.S. (Lehigh); Capt. Burton L. Garrett, B.S. (Missouri); Capt. Lawrence Haller, B.S. (U.S. Military Academy).
Instructors. Capt. Brooks Breese, M.A. (Villanova); SSG Kenneth Underwood.

The Department of Military Science, established in 1919, conducts the Army Reserve Officer Training Corps (ROTC) program at Lehigh University. This is one of the oldest ROTC programs in the nation. The Army ROTC programs provide a means for students to qualify for a commission as an officer in the Active Army, Army Reserve, or Army National Guard.

The objectives of the military science program are to develop leadership and management ability in each student; to provide a basic understanding of the Army's history, philosophy, organization, responsibilities, and role in American society; and to develop fundamental professional knowledge and skills associated with officership. These objectives are achieved through classroom instruction, leadership laboratories, adventure-type field trips, role playing, leadership simulations, and individual assessment and counseling.

Army ROTC offers a four-year program and a two-year program. The four-year program consists of a two-year basic course and a two-year advanced course. The two-year program consists of the two-year advanced course offered to students with previous military experience, and those who have successfully completed a six-week ROTC basic summer camp. Basic course students incur no obligation for service in the Army as a result of taking these courses.

Basic Course. The basic course, normally taken in the freshman and sophomore years, provides training and instruction in leadership and basic military subjects, such as the Army's role and organizational structure, history and philosophy of the Army, basic tactics, land navigation, first aid, group dynamics, and leadership traits and characteristics. Basic course students incur no military obligation.

Advanced Course. The advanced course is normally taken in the junior and senior years. The instruction includes management, military skills, advanced leadership logistics, administration, military law, ethics, and professionalism, and includes attendance at ROTC Advanced Camp. Students receive $100 per month subsistence pay during the junior and senior years.

To enroll in the advanced course, an applicant: completes either the basic course or the six-week basic summer camp; or has received basic course credit for previous military experience; and is accepted for enrollment by the university and the department of military science.

Uniforms and Equipment. All uniforms and equipment needed by the student for military science courses are supplied by the department. Students are charged only for those items not returned when they leave the program.

Transfers. Qualified students transferring from another institution may enter the ROTC program at the appropriate advanced level and year, provided they have received the necessary credits, the recommendation of their former professor of military science (if applicable), and the approval of the university.

Obligation after graduation. Usually upon graduation a student will receive a reserve commission as a second lieutenant and will serve on active duty for three years. Depending on Army requirements, a three- to six-month active duty for training period with an eight-year reserve commitment is offered. Recipients of a Regular Army commission serve at least three years on active duty. Scholarship students agree to accept a Regular Army commission if offered and serve four years on active duty. Graduates accepted for the Army aviation program serve at least three years on active duty after completing studies at the Army Aviation School at Fort Rucker, Ala.

Graduate studies. ROTC graduates may request to delay their active service to pursue a full-time course of instruction leading to an advanced degree. Delay does not lengthen the active service obligation unless the degree is obtained at government expense.

Course credit. Students in the College of Arts and Science and the College of Business and Economics may substitute military science advanced credits for six hours of electives. In the College of Engineering and Applied Science , six credits of advanced ROTC work are permissible within the normal program of each student, irrespective of curriculum. For curricula that include more than six hours of personal electives in the junior and senior years, inclusion of the more than six hours of ROTC credit with normal programs can be effected only with the approval of academic advisers. Two credit hours may be allowed for apprentice teaching in addition to the six hours of electives aforementioned. All military science credits, including those in the basic course, apply toward the student's over-all cumulative average.

Career Opportunities

Individuals may be commissioned as officers in the United States Army after completion of the ROTC program and the advanced camp. Those cadets who may not have completed a bachelor's degree upon qualifying for commissioning will not begin active duty until completion of the degree requirements. The majority then qualify for active duty in the Army in branches (specialities) such as the Corps of Engineers. Military Intelligene, Ordnance, Aviation, Finance, Field Artillery, Armor, Infantry, Medical Service Corps, Nursing, or eight other major fields. Officers work as leader/managers, specialists, or combinations of the two depending on the assignment.

There are opportunities for advanced military and civilian schooling beginning with nearly three months of training in the branch specialty. A person may also receive an additional specialty in such areas as systems analysis, construction engineering, foreign area specialization, or comptroller, depending on individual expertise. Students may be selected for reserve forces duty. Reserve forces duty provides the student with the opportunity to maintain the options of a military or civilian career upon completion of the program. Those individuals who receive reserve forces duty become

officers in the Army Reserve or Army National Guard in their hometown area and essentially have a part-time military career. An officer can earn retirement through both programs after twenty years of service.

Physical facilities. Army ROTC uses areas on and adjacent to the university campus to conduct field training. These locations are excellent for most outdoor activities such as orienteering, patrolling, and survival training. Fort Indiantown Gap Military Reservation, located east of Harrisburg, Pa., is used for some field training exercises and weapons familiarization during one of two annual weekend trips. The other trip is usually taken to another active Army installation such as Ft. Belvoir, Virginia, and Aberdeen Proving Ground, Maryland. Other locations in Pennsylvania used for cadet adventure training are: Ralph Stover State Park (Mountaineering); Delaware and Lehigh rivers (rafting); and the university's Saucon Valley athletic complex.

Programs and Opportunities

ROTC Scholarship Program. This program is designed to offer financial assistance to outstanding young men and women entering the ROTC program who are interested in an Army career. Each scholarship provides full tuition, a textbook and supplies allowance, and laboratory fees, in addition to pay of $100 per month for the period the scholarship is in effect. Three- and two-year scholarships are available to outstanding cadets who are currently enrolled in the four-year ROTC program and are completing either their freshman or sophomore years of college. This program is also open to all qualified students who are not currently enrolled in Army ROTC.

Four-year scholarships are open to all students entering ROTC as freshmen. Recipients of an ROTC scholarship are required to complete at least one semester of Indo-European or Asian language prior to commissioning. Applications for scholarship must be made to Headquarters, U.S. Army Training & Doctrine Command, Fort Monroe, VA by August 15th prior to the senior year for early selection, but no later than December 1st for normal application. Application booklets are available from most high school guidance offices, or may be obtained from the Military Science Department of the University.

Two-Year Program. Students who want to enroll in ROTC after their sophomore year may apply. Applicants must successfully complete a six-week basic ROTC summer camp and have two years of undergraduate or graduate studies remaining. The student is paid for the six-week encampment and receives transportation costs to and from the camp. Individuals begin the advanced course after the basic camp.

Distinguished Military Graduate (DMG) program. This is a competitive program that permits outstanding ROTC students to apply for a Regular Army commission immediately upon graduation. At the end of the junior year and upon completion of the advanced summer camp, approximately one tenth of each senior ROTC class may be designated as Distinguished Military Students (DMS). A student who maintains the same high standards throughout the senior year may qualify for designation as a Distinguished Military Graduate (DMG) and may be offered a Regular Army commission upon graduation.

Off-campus U.S. Army Training Schools. Cadets may be selected to attend the following U.S. Army Schools: Airborne School (Fort Benning, Georgia), Air Assault School (Fort Campbell, Kentucky), Ranger School (Georgia and Florida), and Northern Warfare School (Fort Greely, Alaska). This off-campus program is fully funded by the U.S. Army.

Minor in Military Science. A minor in Military Science is available in the College of Arts and Science. A minor in Military Science consists of 31 credit hours beyond basic Military Science and is designed to provide the student with an academic foundation necessary to support continued intellectual growth and stimulate future inquiry in the realm of civil military affairs and Military Science. Credit hours required are distributed as follows:

Military Science (13)

MS 101	Advanced Military Skills (3)
MS 102	Advanced Leadership (3)
MS 113	Military Command and Staff (3)
MS 114	War, Morality, Ethics and Military Professionalism (3)
MS 118	Special Topics for the Army Officer (1)

History (3)

Hist 310	American Military History (3)

International Relations (3) (Select one of the following)

IR 1	World Politics: Evolution of the International System (3)
IR 2	World Politics: Concepts and Principles (3)
IR 51	American Foreign Policy Since 1945 (3)
IR 312	World Affairs Since 1945 (3)
IR 371	Reading in International Relations (3)

Written Communications (3) (Select one course from one of the following categories)

Creative Writing
Scientific Writing
Writing for Mass Communications

Human Behavior (3) (Select one course in one of the following categories)

General Psychology
Sociology
Anthropology
Ethics

Indo-European or Asian Language (6)

Commissioning Requirements

Individuals must complete either the two- or four-year programs, attend the advanced camp, and receive a college degree, have a CUM GPA of 2.0, and complete all professional military education requirements to become commissioned officers in the United States Army.

Course Descriptions

Leadership Laboratory is conducted for all students on Monday afternoons. The Leadership Laboratory provides students the opportunity to demonstrate an understanding of the leadership process.

Instruction at several levels on a variety of subjects with military application provides the context within which students are furnished opportunities to both teach and lead in a group setting. Responsibility is expanded as the student progresses through the program. In the senior year, the students assume the responsibility for the planning, preparation and conduct of the laboratory.

15. The Soldier in Modern Times (1) fall
The American Army as an institution, its roots, history, customs and traditions and philosophy of leadership. Emphasis on development and role of a professional officer corps. Includes leadership laboratory.

16. Leadership Assessment and Group Dynamics (1) spring
Role of individual and leader within the group, leader traits and characteristics. Emphasis on problem solving and application.

23. Topographic Analysis and Land Navigation (2) fall
Maps as tools in basic terrain analysis and as navigational aids. Emphasis on application and field exercises at individual and small group levels.

24. Leadership Theory and Development (3) spring
Contemporary theories, traits and principles. Leadership philosophies, communications, leader-follower relationships, and leadership problem-solving. Leadership simulations.

101. Advanced Military Skills (3) fall
Essential junior officer skills: advanced land navigation, principles of war, small unit tactical planning, tactics and techniques of the soldier, team leading techniques, oral communications and trainer skills. Emphasizes application and field experience. Prerequisite: permission of department chairman.

102. Advanced Leadership (3) spring
Critical examination of leadership qualities, traits and principles with emphasis on military environment. Self, peer, and instructor leadership evaluation. Advanced military skills reinforced. Prerequisite: permission of department chairman.

Advanced ROTC Summer Camp
This is a six-week training program conducted at Fort Bragg, N.C. Prerequisites are completion of the basic military science courses or their equivalent and MS 105 and 106. The summer camp experience, in coordination with respective engineering curricula, may be used to fulfill the industrial employment requirements of the engineering courses ChE 100, CE 100, EE 100, IE 100, ME 100, and Met 100. Nursing students spend their six-week camp working and training in an Army hospital.

113. Military Command and Staff (3) fall
Role, authority and responsibility of military commanders and staff in Personnel, Material and Training Management; Military Law; Plans and Operations. Staff procedures, problem solving, decision making and training methods used in military management. Prerequisite: permission of department chairman.

114. War, Morality, Ethics and Military Professionalism (3) spring
Development of the Profession of Arms, its fundamental values and institutions. Ethical responsibilities of military professionals in contemporary American society. Moral dimensions of war, just war theory and international law of war. Prerequisite: permission of department chairman.

118. Special Topics for the Army Officer (1) spring
Seminar covering special problems and issues dealing with responsibilities of the commissioned officer as leader, manager, and mentor, not covered in other courses. Prerequisite: permission of the department chairman.

Modern Foreign Languages

Professors. Anna Pirscenok Herz, Ph.D. (Pennsylvania), *chairperson, Russian;* David W. P. Lewis, Dr. de l'Univ. (Sorbonne, Paris), *French;* Anje C. van der Naald, Ph.D. (Illinois), *Portuguese and Spanish.*
Associate professors. Linda S. Lefkowitz, Ph.D. (Princeton), *Spanish;* D. Alexander Waldenrath, Ph.D. (Berkeley), *German;* Lenora D. Wolfgang, Ph.D. (Pennsylvania), *French.*
Assistant professors. Marie-Sophie Armstrong, Ph.D. (Oregon), *French;* Therese Decker, Ph.D. (Harvard), *German,* David W. Pankenier, Ph.D. (Stanford), *Chinese;* Antonio Prieto, M.A. (Princeton), *Spanish;* Eric Williams Ph.D. (Berkeley), *German.*
Adjunct professor. Victor M. Valenzuela, Ph.D. (Columbia), *Latin-American Studies.*
Adjunct lecturer. Harriet L. Parmet, M.Sc. Ed. (Temple), *Hebrew.*

Languages shown above in *italics* indicate the language normally taught by that faculty member.

Command of foreign languages not only gives the student a deeper insight into his or her native tongue but also opens the door to other cultures, traditions and modes of thought. Knowledge of languages is valuable in a broad range of professions. Linguistic skills are important in journalism, government, international relations, law, the armed forces and international business. The specialist may become a translator, interpreter or teacher. A bachelor of arts degree with a major in languages can be a stepping stone to graduate school in other fields such as law and business. Finally, an ability to read foreign languages is important and often required for research in science and technology. In short, language skills are personally enriching and enhance career prospects.

Languages offered

Lehigh offers Mandarin Chinese, French, German, Hebrew, Brazilian Portuguese, Russian and Spanish. Japanese is available through the Lehigh Valley Association of Independent Colleges (see below).

Courses include writing and speaking, reading and listening, literature, civilization and professional areas such as business and health careers. A number of cultural courses are given in English, but most offerings stress classroom use of the language. Facilities include residences for foreign language groups. Foreign language clubs are given to all students. The department has a modern language laboratory. Computer facilities are available.

Language Requirements

The B.A. distribution requirements include a category for foreign language. (see Section III).
Requirements for the B.A. and B.S. in chemistry include German (preferred), French or Russian.

The honors major in international relations requires foreign language study. The College Scholar program in the College of Arts and Science; the minors in Latin American studies and in military science require language study. Students taking the B.A. in international relations or in foreign careers are expected to study a language. Students choosing a foreign language at elementary level towards their general studies requirement in the College of Engineering must take a minimum of one year (two courses). Some doctoral programs also require foreign language competence, usually assessed by the department of modern foreign languages.

Advising. Because of the sequential nature of language study and the variety of specializations available, the department pays special attention to student advising. Students whose experience, skills and placement scores (Advanced Placement or College Board Achievement Test) do not give them a clear indication of their level of placement should consult with their instructor or the department chairperson. Faculty members responsible for more advanced advising are currently as follows: graduate students, Lewis; French major and minor, Wolfgang; German major, Waldenrath; German minor, Decker; Russian minor and area studies, Herz; Spanish major, van der Naald, and minor, Lefkowitz. Both resident and faculty advisers are assigned to foreign language houses and clubs.

Major programs. The department offers major programs in French, German and Spanish. The candidate for the major is expected to demonstrate adequate written and oral command of the language, as well as knowledge of its literature and culture. A period of study abroad is strongly recommended.

Double majors and Arts-Engineering majors including a language component are well received by employers. Studies in the two areas are carefully coordinated by major advisers.

Minor programs. The department offers minor programs in French, German, Russian and Spanish and coordinates these studies with a student's major requirements in any college.

Related programs. These are available in East Asian studies, Foreign Careers, Jewish Studies, Latin American Studies and Russian Studies.

Language of instruction. All courses are taught in the target language unless otherwise indicated. Students are thereby rapidly accustomed to considering the language as an active means of communication and not solely as an object of study.

Courses in English. The department offers elective courses in English on literary, cultural and social subjects. These courses have no prerequisite and may, in most cases, be taken

to fulfill preliminary distribution requirements. One of these courses may be included in the major.

Study Abroad and Foreign Study Awards. The department encourages students of foreign languages to spend a summer, a semester, or a full year on an approved program of study abroad. The department offers a limited number of travel scholarships for foreign study to qualified students. Applications should be submitted by November 1 for the spring semester and by March 1 for summer or fall. For credit, transfer students must consult in advance with their major adviser, foreign language adviser, other appropriate departments, the associate dean of Arts and Science, the registrar, and when appropriate, the Office of Financial Aid.

A selective program of foreign summer internships is being developed.

Lehigh offers summer programs through the Lehigh Valley Association of Independent Colleges (LVAIC). Programs are offered in Poitiers (France), Bonn (Germany) and Seville (Spain) for six credits each. A faculty member, acting as program director, accompanies the students. Courses are taught at intermediate and advanced levels, by qualified instructors from host institutions. Summer programs sponsored by the Lehigh-LVAIC Center for Jewish Studies offer the possibility of studying Hebrew in Israel (see Section III).

Credits and grades are fully transferable under normal LVAIC cross-registration procedures. Interested students should consult with the department of modern foreign languages, Coppee Hall.

Campus foreign language houses. Foreign language residences are recognized, together with the International House, as an important feature of campus life. Students are encouraged to participate in weekly open dinners and to consider living there.

Foreign Culture and Literature Taught in English

These courses on foreign cultures and comparative topics carry no prerequisites; knowledge of the foreign language is not required.

Language majors may take one course taught in English by the department for credit toward a major requirement. Interested students should consult their language major advisers.

MFL 21. Russian Literature and Culture I (3)
Customs, institutions and literary contributions to western civilization. Herz

MFL 22. Russian Literature and Culture II (3)
Continuation of MFL 21. Herz

MFL 31. Masterpieces of French Literature (3)
Main genres in French literature: Arthurian romance, essay, poetry, theater, novel and short story. Readings and discussion.

MFL 33. The French-Speaking World Today (3)
Modern France and the French-speaking world: culture, values, problems and modes of thought from Paris to Marseilles, from Quebec to Senegal.

MFL 43. German Literature in Translation (3)
One period or theme in German literature.

MFL 44. Pennsylvania German Culture (3)
Cultural contribution of Pennsylvania Germans: their history, literature, art, music and politics. Waldenrath

MFL 51. Contemporary Hispanic-American Literature (3)
Reading and discussion of distinguished Latin American writers: Borges, Garcia Marquez, Cortazar and Vargas Llosa.

MFL 53. The Hispanic World and Its Culture (3)
Characteristics and values of the people of Spain and Latin America in literary works and other material. Hispanic cultural contributions to Western civilization.

MFL 61. Cultural Mosaic of Modern Israel (3) annually
Cultural and religious components of the State of Israel: creative and performing arts and sociological patterns such as population, immigration, ethnic diversity and literature.

MFL 71. Introduction to Chinese Culture (3)
Traditional Chinese attitudes and other concepts. Pankenier

MFL 81. Brazil and its Culture (3)
Cultural development in Brazil, from colonial times to the present. van der Naald

MFL 321. Russian Realism (3)
Russian realists of the 19th century; Dostoevsky, Turgenev, Tolstoy, *et al.* Lectures and class discussion in English; collateral reading and written reports in Russian or English. Herz

MFL 322. Contemporary Soviet Literature (3)
Socialist realism in Russian literature since 1917. Lectures and class discussion in English; collateral reading and written reports in Russian or English. Herz

Chinese

The department offers the following courses in Mandarin Chinese. A course in Chinese culture taught in English is listed above, MFL 71. For East Asian studies see page 29.

Chin 1. Elementary Chinese I (4)
Spoken and written Mandarin Chinese; the standard romanized transcription system used in the People's Republic; Chinese characters. Basic speech patterns, vocabulary and pronunciation. One weekly laboratory hour. Pankenier

Chin 2. Elementary Chinese II (4)
Continuation of Chin 1; more advanced vocabulary and sentence structures. One weekly laboratory hour. Prerequisite: Chin 1 or equivalent. Pankenier

Chin 11. Intermediate Chinese I (3)
More advanced character texts. folklore, brief readings in Chinese and articles in the vernacular. Pankenier

Chin 12. Intermediate Chinese II (3)
Continuation of Intermediate Chinese II; more formal oral and written exercises in the vernacular. Prerequisite: Chin 11 or equivalent. Pankenier

French

Preliminary courses. These may be replaced by advanced standing for students who qualify.

Fren 1	Elementary French I (4)
Fren 2	Elementary French II (4)
Fren 11	Intermediate French I (3)
Fren 12	Intermediate French II (3)

Requirements for the major. A minimum of thirty credit hours is required beyond Fren 12, as follows:
Fren 43 and 44, Advanced Oral and Written French (6)
Fren 151 and 152, Survey of Literature (6)
Two or three courses from the following: Fren 159, 191, 245, 247, 291, MFL 31, 33, (6-9). (Only one course taught in English may be included.)
Three or four courses at the 300 level (9-12).

Requirements for the departmental honors major. Thirty-six credit hours are needed. Requirements are the same as for the major, plus six additional hours of advanced literature and a 3.50 average in the major.

Recommended related courses. Students majoring in French are urged to take elective courses on related subjects, either within or outside the department, as approved by their adviser.

Requirements for the minor. Fifteen credit hours are required above Fren 12 as follows:
Fren 43 (3)
Two or three of 44, 46, 151, 152, 159, 191, 245, 247 (6-9)
One or two courses at 200 or 300 level. (3-6)

Requirements for advanced courses. Except where otherwise noted, 200 or 300-level courses are open to students having completed six credit hours of French beyond Fren 12. Exceptions require the consent of chairperson.

Language of instruction. Courses are normally conducted in French. Courses in French culture taught in English are listed under Foreign Culture above, MFL 31, 33.

Undergraduate Courses in French

Fren 1. Elementary French I (4) fall and spring
Basic conversational French, illustrating essential grammatical principles, reading simple texts and writing. Language laboratory practice.

Fren 2. Elementary French II (4) fall and spring
Continuation of Fren 1. Prerequisite: Fren 1 or appropriate Achievement Test score before entrance, or consent of the chairperson.

Fren 11. Intermediate French I (3) fall and spring
Completion of grammar and grammar review. Readings and discussion. Prerequisite: Fren 2 or appropriate Achievement Test score before entrance, or consent of chairperson.

Fren 12. Intermediate French II (3) fall and spring
Emphasis on readings and discussion. Prerequisite: Fren 11, or appropriate Achievement Test score before entrance, or consent of chairperson.

Fren 41. French Pronunciation (1)
Correct pronunciation of French: the obstacles commonly encountered by American speakers. Articulation, rhythm and pitch. Introduction to the International Phonetic Alphabet. Laboratory work. Prerequisite: any French course previously or concurrently.

Fren 42. Grammar (1)
Intensive review of the fundamentals of French grammar. Prerequisite: Equivalent of Fren 2. May be taken for credit only if no previous degree credit in French has been granted; may be audited by others.

Fren 43. Advanced Oral and Written French I (3) fall
Intensive practice in written and oral French. Prerequisite: Fren 12, or Achievement Test score of 570 or consent of chairperson.

Fren 44. Advanced Oral and Written French II (3)
Continuation of Fren 43, with emphasis on oral work. Prerequisite: Fren 43 or consent of chairperson.

Fren 46. French for Business and Foreign Careers (3)
For students who want "professional" French but are uncertain of their readiness for highly specialized material. Intensive revision of grammar, reading of simple contemporary texts, conversation, composition and letter writing. Prerequisite: Fren 12 or consent of the chairperson. Lewis

For Advanced Undergraduates And Graduate Students

Fren 151. Survey of French Literature I (3)
From the Middle Ages through the 18th century. Prerequisite: Fren 12 or consent of the chairperson. Wolfgang

Fren 152. Survey of French Literature II (3)
Representative works of the 19th and 20th centuries. Prerequisite: Fren 151 or consent of the chairperson.

Fren 159. The French-Speaking World and Its Culture (3)
Cultural, social and artistic development of France and the French-speaking world. Prerequisite: Fren 12.

Fren 181. French Cultural Program (1-6)
A summer program abroad. Formal instruction in the French language and direct contact with the people and their culture during one or two months in a French-speaking country. (For LVAIC courses, see Fren 191 below.)

Fren 221. *L'Evasion*: Fantasy and Escapism in French Literature (3)
Psychological and artistic study of the writer's eternal search for the ideal world. Prerequisite: any of Fren 43, 44, 151, 152, 159. Lewis

Fren 223. Love and the French Novel (3)
Representative works from each period of French literature from *Tristan et Iseult* and *La Princesse de Clèves* to Gide's *L'Immoraliste*. Style, themes, myths and story patterns are analyzed. Prerequisite: any of Fren 43, 44, 151, 152, 159. Wolfgang

Fren 245. Advanced French for Business and Foreign Careers (3)
Understanding and writing French for business and international affairs. Readings and oral presentations of current interest, with technical vocabulary (marketing, finance, industry, communications, transport, law, energy, economic relations, environment, etc). Prerequisite: any of Fren 43, 44, 46, 159 or consent of chairperson. Lewis

Fren 268. World Literature Written in French (3)
Major authors from areas outside Europe, such as Canada, Africa, and the Caribbean. Prerequisite: any of Fren 43, 44, 151, 152, 159.

Fren 271. Readings (3)
Study of the works of some author or group of authors or a period, or of a literary theme. May be repeated once for credit. Prerequisite: Fren 12 or consent of the chairperson.

Fren 281. French Cultural Program (1-6)
A program in a French-speaking country offering formal language courses and cultural opportunities. (For LVAIC courses, see Fren 291 below.) Prerequisite: consent of the chairperson.

Fren 301. Advanced Composition and Translation (3)
Techniques of translation. Literary, political, and technical texts. Essay-writing techniques and free composition. Prerequisite: a 200-level course or consent of the chairperson.

Fren 303. Renaissance Poetry (3)
Study of the major poets of the period. Wolfgang

Fren 305. Prose in the 16th Century (3)
Analysis of fiction, memoirs, historical documents, including the works of Rabelais, Montaigne, and Marguerite de Navarre. Wolfgang

Fren 309. Medieval French Literature (3)
Introduction to Old French from *La Chanson de Roland* to Françoi Villon. Wolfgang

Fren 311. French Classicism (3)
French classical theater, novel and criticism, with emphasis on Corneille, Racine, Molière, Pascal, Lafayette, Malherbe and Boileau.

Fren 312. French Classicism (3)
Continuation of Fren 311. Prerequisite: Fren 311 or consent of the chairperson.

Fren 313. The Age of Enlightenment (3)
The *Philosophes* and *Encyclopédistes* of the 18th century, with emphasis on Voltaire, Rousseau, Montesquieu and Diderot.

Fren 314. The Age of Enlightenment (3)
Continuation of Fren 313. Prerequisite: Fren 313, or consent of chairperson.

Fren 315. 19th Century Poetry (3)
Parnassian, Symbolist and Post-Symbolist eras. Lewis

Fren 317. The Romantic Movement (3)
The Romantic movement in France with readings from its principal exponents. Lewis

Fren 318. Drama in the Twentieth Century (3)
Contemporary French drama with an analysis of its origins and movements. Armstrong, Lewis

Fren 319. Twentieth Century Novel and Poetry (3)
Detailed study of representative major works. Armstrong

Fren 370. Internship (1-6)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in French-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisites: French 43 or 44 and approval of faculty committee on intership.

Fren 371. Independent Study (1-4)
Special topics under faculty guidance. May be repeated once for credit. Prerequisite: consent of the chairperson.

German

Preliminary courses. These may be replaced by other courses when a student qualifies for advanced standing.

Germ 1	Elementary German I (3)
Germ 2	Elementary German II (3)
Germ 11	Intermediate German I (3)
Germ 12	Intermediate German II (3)

Requirements for the major. A minimum of thirty credits beyond Germ 12 of which three credits must be a junior year writing course in the German section. Emphasis should be upon 200 and 300 level courses.

Requirements for the departmental honors major. Requirements are the same as for the major, plus: two additional advanced courses at the 300 level; dissertation or comprehensive examination (written or oral); an average of 3.50 in courses in the major.

Recommended related courses. Students majoring in German are urged to take courses on related subjects, either within or outside the department, as approved by their adviser.

Requirements for the minor. Fifteen credits above Germ 12 are required including at least one at 300-level.

Requirements for advanced courses. The prerequisite for all 200-level courses is at least one three-credit course taught in German beyond Germ 12 or equivalent. The prerequisite for all 300-level courses is at least two three-credit courses beyond Germ 12 (course in English excluded) or equivalent. Prerequisite may be waived by consent of the chairperson.

Language of instruction. Courses are normally conducted in German. Courses conducted in English are listed under MFL courses.

Undergraduate Courses in German

Germ 1. Elementary German I (3)
Fundamentals of German; reading of simple texts; simple conversation and composition; vocabulary building. Three class hours plus one laboratory or drill hour each week. No previous German required.

Germ 2. Elementary German II (3)
Continuation of German 1, including reading of more advanced texts. Three class hours plus one laboratory or drill hour each week. Prerequisite: Germ 1, or two units of entrance German, or consent of the chairperson.

Germ 5. German Pronunciation (1)
Practice in pronunciation, articulation, rhythm and pitch. Includes laboratory practice. Strongly recommend for all students of the language at all levels.

Germ 11. Intermediate German I (3)
Review of grammar, composition, reading of intermediate texts, vocabulary building. Prerequisite: Germ 2 or four units of entrance German or consent of chairperson.

Germ 12. Intermediate German II (3)
Continuation of Germ 11. Prerequisite: Germ 11 or consent of chairperson.

Germ 63. Introduction to German Culture (3)
Lectures, readings and discussion of selected aspects of German culture. Prerequisite: Germ 12 or equivalent, or consent of chairperson.

Germ 65. Introduction to the German Literary Tradition (3)
Representative works from one or more of the major periods of German literature. Prerequisite: Germ 12 or equivalent, or consent of chairperson.

Germ 67. Conversation and Composition (3)
Intensive practice in oral and written German. Prerequisite: Germ 12 or equivalent, or consent of chairperson.

Germ 81. German Cultural Program (1-6)
Summer program abroad. Formal instruction in the language and the culture of a German speaking country.

For Advanced Undergraduates And Graduate Students

Germ 201. Survey of German Literature I (3)
German literature to the second half of the 18th century. Readings, literature and discussion of representative works.

Germ 202. Survey of German Literature II (3)
From the Age of Goethe to the present. Readings, lectures and discussion of representative works.

Germ 211. Introduction to German Drama (3)
Drama as a literary genre; plays from various periods of German Literature.

Germ 214. Goethe's "Faust" (3)
Study of Goethe's play with an introduction to the Faust tradition.

Germ 241. Advanced Composition and Conversation (3)
Conducted in German.

Germ 250. Special Topics (1-3)
Literary and linguistic topics not covered in regular courses. May be repeated for credit.

Germ 281. German Cultural Program (1-6)
Study abroad. Formal instruction in German and direct contact with the people and their culture during at least one month in a German-speaking country. Prerequisites: Germ 63, 65, or 67, or consent of the chairperson.

Germ 301. Medieval German Literature (3)
Lectures and readings in medieval literature in translation. Introduction to Middle High German.

Germ 302. Renaissance, Reformation and Baroque (3)
Writers and literary movements from the end of the Middle Ages through the Baroque.

Germ 303. German Romanticism (3)
Early and late Romanticists.

Germ 304. Literature of the GDR (3)
Representative East-German writers.

Germ 305. 20th-Century German Literature (3) fall
Topics in German literature of the 20th century.

Germ 325. 19th-Century German Literature (3)
Representative writers of post-Romanticism.

Germ 341. Advanced Phonetics, Linguistics, Composition, Conversation and Translation (3)
Essay writing and translation from and into German.

Germ 344. The Age of Enlightenment and Classicism (3)
Selected works of the period.

Germ 350. Special Topics (1-3)
Literary or linguistic topics not covered in regular courses. May be repeated once for credit. Prerequisite: permission of the chairperson.

Germ 370. Internship (1-6)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in German-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisite: German and/or approval of the staff in German and of the faculty committee on internship.

Hebrew

The department offers courses both separately and in the context of the Jewish Studies minor (see page 30).

Language of instruction. Courses are normally conducted in Hebrew. A course in Hebrew culture taught in English is listed under Foreign Culture above, MFL 61.

Hebr 1. Elementary Modern Hebrew I (3) fall
Classroom and laboratory instruction to develop hearing, speaking, reading and writing the language. Cultural, ethnic and religious dimensions of Israeli society. Tapes, textural materials, short stories. No previous study of Hebrew required.

Hebr 2. Elementary Modern Hebrew II (3) spring
Continuation of Hebrew 1 utilizing the audio-lingual approach. Fundamentals of the language, structure and sounds; the Hebrew verb; reading and vocalized stories; written exercises; tapes; short stories. Prerequisite: Hebr 1 or its equivalent.

Hebr 11. Intermediate Modern Hebrew I (3) fall
Classroom and laboratory instruction to develop fundamental patterns of conversation and grammar; composition, reading of texts, laboratory work and sight reading; comprehension, speaking, reading and writing of unvocalized materials. Prerequisite: Hebr 2 or qualifying examination.

Hebr 12. Intermediate Modern Hebrew II (3) spring
Continuation of Hebrew 11. Reading of texts, including selected short stories, outside reading and supplementary material; increased emphasis on oral presentation. Prerequisite: Hebr 11 or approval of the department chairperson.

Japanese

Elementary and intermediate Japanese language and Japanese culture are available at Lafayette College in association with LVAIC. For details consult chairperson.

Portuguese

Language of instruction. Courses are conducted in Brazilian Portuguese. A course in Brazilian culture taught in English is listed above, MFL 81.

Port 1. Elementary Portuguese I (3)
Basic conversational Brazilian Portuguese; principles of grammar and syntax. van der Naald

Port 2. Elementary Portuguese II (3)
Continuation of Portuguese 1. Prerequisite: Port 1 or consent of chairperson. van der Naald

Port 11. Intermediate Portuguese I (3)
Conclusion of grammar presentation. Contemporary readings. Practice in speaking and writing. Prerequisite: Port 2 or consent of the chairperson. van der Naald

Port 12. Intermediate Portuguese II (3)
Grammar review. Readings of Brazilian authors. Emphasis on oral and written fluency. Prerequisite: Port 11 or consent of the chairperson. van der Naald

Port 271. Special Topics (3)
Literary or linguistic topics. May be repeated once for credit. Prerequisite: consent of chairperson. van der Naald

Russian

Requirements for minor. Eighteen credit hours of Russian are required not including MFL 21, 22, 321 or 322. For Russian studies minor, see page 31.

Language of instruction. Courses are normally conducted in Russian. Courses in Russian culture taught in English are listed under Foreign Culture above, MFL 21, 22, 321 and 322.

Russ 1. Elementary Russian I (3) fall
Classroom and laboratory introduction to the fundamentals of conversational and grammatical patterns; practice in pronunciation, simple conversation, reading and writing. Herz

Russ 2. Elementary Russian II (3) spring
Continuation of Russ 1. Prerequisite: Russ 1 or two units of entrance Russian. Herz

Russ 11. Intermediate Russian I (3) fall
Classroom and laboratory practice in conversation. Development of reading and writing skills. Prerequisite: Russ 2 or three units of entrance Russian. Herz

Russ 12. Intermediate Russian II (3) spring
Continuation of Russ 11. Prerequisite: Russ 2 or 11, or four units of entrance Russian. Herz

Russ 31. Russian in Science, Economics, and Industry I (3) fall
Readings and conversations about nonliterary topics including the social and natural sciences, business, economics and industry. Prerequisite: Russ 12. Herz

Russ 32. Russian in Science, Economics, and Industry II (3) spring
Continuation of Russ 31. Prerequisite: Russ 12 or 31. Herz

Russ 41. Conversation and Composition I (3) fall
Intensive practice in oral and written Russian; laboratory practice in aural comprehension. Readings and discussions on Russian literature and culture. Prerequisite: Russ 12, or three units of entrance Russian. Herz

Russ 42. Conversation and Composition II (3) spring
Continuation of Russ 41. Prerequisite: Russ 41. Herz

Russ 251. Special Topics (3) fall
Intensive study of literary or linguistic topics. Prerequisite: Russ 42. May be repeated for credit. Herz

Russ 252. Special Topics (3) spring
Intensive study of literary or linguistic topics. Prerequisite: Russ 42 or 251. May be repeated for credit. Herz

Russ 370. Internship (1-6)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in Russian-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisites: Russ 41 or 42 and approval of faculty committee on internship.

Russ 391. Special Topics (1-3)
Independent study or research under faculty guidance on a literary, linguistic, or methodological topic. May be repeated once for credit. May be used to satisfy the doctoral language requirement. Prerequisites: undergraduate degree and consent of chairperson. Herz

Spanish

Preliminary courses. These may be replaced by other courses if students achieve advanced standing.

Span 1	Elementary Spanish I (3)
Span 2	Elementary Spanish II (3)
Span 11	Intermediate Spanish I (3)
Span 12	Intermediate Spanish II (3)

Requirements for the major. A total of thirty credit hours are required above Span 12 as follows: Span 141, 142 or 255, 151, 152. Span 191 or 291 may be considered.

Four courses at the 300-level: at least two must be selected from Peninsular literature and at least two from Spanish American literature, the remaining two courses at the 100 level and above.

Requirements for departmental honors major. Thirty-six credit hours are required above Span 12 as follows: thirty credits, as for the major; six additional credit hours on the 300 level; a 3.50 average in the major.

Requirements for the minor. Fifteen credits are required above Span 12, as described for three minor tracks.

Spanish American Track. Span 141, 142 or 255, 152, a 300-level course in Spanish American literature, one course at the 100-level or above.

Peninsular Track. Span 141, 142 or 255, 151, a 300-level course in Peninsular literature, one course at the 100-level or above.

Professional Track. Span 141, 142 or 255, 211, 151 or 152, one course at the 100-level or above.

Recommended related courses. Students majoring in Spanish are urged to take courses on related subjects inside or outside the department, as approved by their adviser.

Requirements for advanced courses. The normal prerequisite for 200- and 300-level literature courses in Spanish is Span 151 and/or 152. Exceptions require consent of chairperson.

Language of instruction. Courses are normally conducted in Spanish. Culture courses taught in English are listed under Foreign Culture and Literature Taught in English.

Undergraduate Courses in Spanish

Span 1. Elementary Spanish I (3) fall and spring
Basic conversational Spanish illustrating essential grammatical principles. Reading of simple texts and writing. Students will be required to practice each lesson in the language laboratory.

Span 2. Elementary Spanish II (3) fall and spring
Continuation of Span 1. Prerequisite: Span 1 or equivalent.

Span 11. Intermediate Spanish I (3) fall and spring
Conclusion of grammar presentation. Contemporary readings. Practice of speaking and writing. Prerequisite: Span 2 or equivalent.

Span 12. Intermediate Spanish II (3) fall and spring
Grammar review. Readings of Spanish and Latin American authors. Emphasis on acquiring oral and written fluency. Prerequisite: Span 11 or equivalent.

Span 131. Communicating in Spanish for Medical Personnel (1-3)
For prospective medical personnel communicating with Spanish-speaking patients. Dialogues, health-care vocabulary. Review of grammar. Language laboratory practice. Prerequisite: Span 12 or equivalent. Lefkowitz

Span 133. Phonetics and Pronunciation (1)
Comparison of Spanish and English sounds; descriptions of Spanish vowels and consonants in their various positions. Oral practice in Language Laboratory. Special emphasis on accent and intonation patterns. Prerequisite: Span 2. Staff

Span 141. Advanced Grammar (3) fall
Intensive review of Spanish grammar with stress on finer points. Analysis of syntax and style. Prerequisite: Span 12 or equivalent.

Span 142. Advanced Conversational Spanish (3) spring
Conversational practice stressing the building of vocabulary, based on literary texts and topics of general interest. Designed to stimulate fluent and spontaneous use of spoken Spanish. Prerequisite: Span 12 or equivalent.

Span 151. Cultural Evolution of Spain (3) fall
The historical and cultural evolution of Spain. Discussion of major literary works in their cultural and historical contexts. Prerequisite: Span 12 or consent of chairperson. Lefkowitz or van der Naald

Span 152. Cultural Evolution of Latin America (3) spring
The historical and cultural evolution of Latin America. Prerequisite: Span 12 or equivalent.

Span 162. Women Writers of Latin America (3) spring
The contribution of women writers to Latin American literature. Prerequisite: Span 152.

For Advanced Undergraduates And Graduate Students

Span 211. Practical Business Spanish (3)
For students with a basic knowledge of Spanish: the language in business, law, international and social relations. Letter-writing, comprehension of technical texts, specialized professional vocabulary and review of grammar. Prerequisite: Span 141 or equivalent. Lefkowitz

Span 212. Writing Skills (3)
Improving writing proficiency through practice in composition and translation. Prerequisite: Span 141 or equivalent. Lefkowitz

Span 231. Spanish American Literature (3)
Literature of the pre-Colombian, conquest and colonial periods. Oral and written reports. Prerequisite: Span 151 or 152.

Span 255. Improvisational Theater Games in Spanish
For students who have some fluency in the language and who wish to practice and improve their oral Spanish in a creative setting. Enrollment limited to 15. Prerequisite: Span 141 or equivalent. van der Naald

Span 263. The Spanish American Short Story (3)
Comparative study of the literary problems posed by the work of significant short-story writers such as Quiroga, Borges,

Cortázar Ribeyro, and others. Prerequisite: Span 152. Prieto or Valenzuela

Span 281. Spanish Cultural Program (1-6)
A program abroad. Formal instruction in Spanish grammar, conversation and culture during one or more months in Spain or Latin America on an approved program. (For LVAIC courses, see Span 191 and 291 below.) Prerequisite: Span 12.

Span 303. Don Quijote (3)
Reading and critical analysis. Prerequisite: Span 151. Lefkowitz

Span 305. Spanish Literature of the Middle Ages (3)
Reading and discussion of outstanding works such as *El Cid, El Libro de Buen Amor* and *La Celestina*. Topics vary. Prerequisite: Span 151. Lefkowitz

Span 308. Peninsular Literature Since 1939 (3)
Reading and discussion of representative contemporary Spanish poets, playwrights and novelists. Prerequisite: Span 151. van der Naald

Span 310. Literature of 19th-Century Spain (3)
Poetry, novels and plays that exemplify the literary movements of Romanticism, Realism and Naturalism. Topics vary. Prerequisite: Span 151 or consent of chairperson. van der Naald

Span 317. Twentieth-Century Spanish Theater (3)
Prerequisite: Span 151 or consent of chairperson. van der Naald

Span 320. Literature of the Spanish Caribbean (3)
Study of representative works with emphasis on Cuba and Puerto Rico. Writers include Barnet, Carpentier, Sanchez, and Rodriguez Julia. Prerequisite: Span 152. Prieto

Span 321. Children and Adolescents in Contemporary Spanish American Literature (3)
Discussion of narrative techniques and the category of the self as they relate to the images of adolescence and childhood in works by such authors as Vargas Llosa, Reinaldo Arenas, Jose Bianco, and Silvina Ocampo. Prerequisite: Span 152. Prieto

Span 322. The Short Novel in Contemporary Spanish American Literature (3)
Close reading and discussion of a narrative form which is exemplified by the work of Garcia Marquez, Onetti, Rulfo, Bioy Casares, and others. Prerequisite: Span. 152. Prieto

Span 323. Literature and Revolution in Contemporary Cuba (3)
Study of works written after 1959 by dissident, non-dissident, and exiled authors (Desnoes, Norberto Fuentes, Benitez Rojo, Cabrera Infante). Discussion of problems raised by the social function of intellectuals and of literature, as they relate to themes, modes of writing, genres. Prerequisite: Span 152. Prieto

Span 324. Marginal Groups in Spanish American Literature (3)
Reading and discussion of representative works that portray those who have been excluded from the main culture. Authors to be read are Hernández, Sarmiento, Alegría, Guillén, and Carpentier. Prerequisite: Span 152. Prieto

Span 379. Internship (1-6)
Designed to give advanced qualified students the chance to acquire field experience and training with selected firms and governmental agencies in Spanish-speaking countries. Assigned readings, written reports, and employer performance evaluations are required. Prerequisites: Span 141 or 142 and approval of faculty committee on internship.

Span 391. Special Topics (1-3)
Independent study or research under faculty guidance on a literary, linguistic, or methodological topic. May be repeated once for credit. May be used to satisfy the doctoral language requirement. Prerequisites: undergraduate degree and consent of the chairperson.

LVAIC Summer Programs

These courses are offered under the cooperation agreement with the Lehigh Valley Association of Independent Colleges. They may be incorporated into foreign language majors and minors with the permission of the appropriate advisor.

French

Fren 191. French Language and Culture II Abroad (6)
Intensive practice in France of conversational French, rapid review of basic grammar, the reading and analysis of moderately difficult texts, as well as the development of writing skills, supplemented by the study of selected aspects of contemporary French civilization (LVAIC program). Prerequisites: consent of chairperson and proficiency examination in France.

Fren 291. French Language and Culture III Abroad (6)
Intensive practice in France of spoken and written French, aimed at providing the student with extensive proficiency of expression and the ability to discriminate linguistic usage. Emphasis on idiomatic expressions and an introduction to stylistics. Reading and analysis of more difficult texts. Supplemented by in-depth study of selected aspects of contemporary French civilization (LVAIC program). Prerequisites: consent of chairperson and proficiency examination in France.

German

Germ 191. German Language and Culture II Abroad (6)
Intensive practice in Germany of conversational German, rapid review of basic grammar, the reading and analysis of moderately difficult texts, as well as the development of writing skills, supplemented by the study of selected aspects of contemporary German civilization (LVAIC program). Prerequisites: consent of chairperson and proficiency examination in Germany.

Germ 291. German Language and Culture III Abroad (6)
Intensive practice in Germany of spoken and written German, aimed at providing the student with extensive proficiency of expression and the ability to discriminate language usage. Emphasis on idiomatic expressions and an introduction to stylistics. Reading and analysis of more difficult texts. Supplemented by in-depth study of selected aspects of contemporary German civilization (LVAIC program). Prerequisites: consent of chairperson and proficiency examination in Germany.

Hebrew

For courses in Israel including study of Hebrew, see under Jewish Studies, page 30.

Spanish

Span 191. Spanish Language and Culture II Abroad (6)
Intensive practice in Spain of conversational Spanish, rapid review of basic grammar, the reading and analysis of moderately difficult texts, as well as the development of rudimentary writing skills, supplemented by the study of selected aspects of contemporary Spanish civilization. Prerequisites: consent of chairperson and proficiency examination in Spain.

Span 291. Spanish Language and Culture III Abroad (6) Intensive practice in Spain of spoken and written Spanish aimed at providing the student with extensive proficiency of expression and the ability to discriminate linguistic usage. Emphasis on idiomatic expressions and an introduction to stylistics. Reading and analysis of more difficult texts. Supplemented by in-depth study of selected aspects of contemporary Spanish civilization. Prerequisites: consent of chairperson and proficiency examination in Spain.

Music

Associate professors. Paul Salerni, Ph.D. (Harvard), *chairman;* Jerry T. Bidlack, M.F.A. (Boston U.); Steven Sametz, D.M.A. (Wisconsin).
Assistant professor. Nadine Sine, Ph.D. (N.Y.U.).
Adjunct professor. Nancy S. Bidlack, M.M. (Temple).
Adjunct lecturer. Jung-ho Pak, M.M. (U.S.C.).
Marching Band director. Clark J. Hamman, B.S. (Wilkes).
Instrumental instructors. Jeffrey Winter, bassoon; Allison Herz, clarinet; Elaine Martin, flute; Frank DiBussolo, electric guitar; Richard Metzger, guitar; Carol Temlin, oboe; James Thoma, percussion; Helen Beedle, piano; Sandra Shuler, piano; Robert Dennison, piano; Michael Trach, saxophone; Dominic Fiore, string bass; James Brown, trombone; Lawrence Wright, trumpet; Clark Hamman, tuba; Rohan Smith,, violin, viola; Nancy Bidlack, violoncello; Jeanette Thompson, voice.

Located in Lamberton Hall, the music department offers courses in music history, literature, theory, and composition, in addition to providing a wide range of performance experience in instrumental and vocal ensembles, and private instruction. Lamberton houses a listening library, practice rooms, a small collection of instruments, an electronic studio, a computer assisted ear-training facility, and a large concert and rehearsal room.

A student graduating with the music major will have gained a strong foundation in the basics of music theory and substantial exposure to the style and repertoire of Western music from the Middle Ages to the present. This curriculum will prepare a student to continue graduate studies in musicology, music theory, or composition. A music major taken in conjunction with a business major may lead to a variety of careers in arts management or in the recording and music publishing industries. Some students may find that a double major or a minor in music will provide the basis for a life-long involvement with an art form which does not necessarily generate income, but gives lasting enjoyment.

Major program. Students majoring in music must take 26 credit hours (beyond Mus 20 and 81), which include one three-credit and two four-credit courses in music theory and three three-credit courses in music history. The remaining two three-credit courses in the major are elective. Although one-credit courses in performance and private instrument and voice instruction do not count toward the major, the Music Department encourages majors to take advantage of these opportunities.

Minor programs. Five three-credit courses are required for the minor, and may include Mus 20 and 81. Providing they meet the prerequisites, students may take any five courses from the department offerings. A minor must take at least one course from among the theory offerings (Mus 81, 111, etc.) and at least one from the music literature courses (Mus 20, 131, 132, etc.).

Private lessons. A wide variety of instruments and voice lessons may be taken for one credit. They must be arranged through the department at set fees that are *not* included in tuition.

Performing groups. Admission to band, choir, ensembles, and orchestra is by audition, and students receive one credit per semester by registering for the appropriate course number. Although there is no limit to the number of courses in this series that may be taken, students should check with their advisor to determine the number that may be applied toward graduation (e.g. only eight credits are applicable in the College of Arts and Science). Performing credits do not count toward the major or humanities distribution requirements.

Music at Lehigh. The department sponsors *Music at Lehigh,* a professional concert series of about ten performances a year open to students and public without charge. Recent appearances include the Orpheus Chamber Orchestra; Calliope, A Renaissance Band; and the Performer's Committee for Twentieth-Century Music. The Ralph N. Van Arnam Chamber Music Series, inaugurated in 1980, presents several concerts each year.

Course Offerings

20. Introduction to Musical Literature (3) fall-spring
Musical style approached through works from the Middle Ages to the present studied in historical and social settings. Emphasis on listening techniques and aquaintance with the masterpieces of Western music. Sine

21-78. Applied music and performance courses may be repeated for credit up to eight times. Prerequisite: consent of the chairperson or audition by faculty member responsible for the course.

21. Marching Band (1) fall
22. Concert Band (1) spring
23. Varsity Band (1) spring
31. University Choir (1) fall-spring
32. Choral Union (1) fall-spring
41. String Ensemble (1) fall-spring
42. Woodwind Ensemble (1) fall-spring
43. Brass Ensemble (1) fall-spring
44. Baroque Ensemble (1) fall-spring
45. RenaissanceEnsemble (1) fall-spring
46. Ensemble with Piano (1) fall-spring
47. Vocal Ensemble (1) fall-spring
48. Mixed Ensemble (1) fall-spring
61. String Orchestra (1) fall-spring
71. Private Piano Study (1) fall-spring
72. Private Vocal Study (1) fall-spring
73. Private String Study (1) fall-spring
74. Private Woodwind Study (1) fall-spring
75. Private Brass Study (1) fall-spring
76. Private Percussion Study (1) fall-spring
77. Private Organ Study (1) fall-spring
78. Other Private Study (1) fall-spring

81. Fundamentals of Music Theory (3) fall-spring
Introduction to rhythm, pitch and timbre; melody, counterpoint and harmony; analysis, composition, ear training, keyboard harmony, and sight singing. Bidlack

111. Theory I: Principles of Harmonic Analysis (3) fall-spring
Exercises in counterpoint and harmony. Ear training, keyboard harmony, sight singing, and analysis. Prerequisite: Mus 81 or equivalent. Sametz

131. Major Genres (3) fall or spring
Evolution of a single kind of musical composition. Title varies: Opera, Symphony, etc. May be repeated for credit as title varies. Prerequisite: Mus 20, or 81, or consent of the chairperson.

132. Composer and Era (3) fall or spring
Life and development of a composers's style viewed in historical context. Title varies: Bach, Beethoven, Mozart, etc. May be repeated for credit as title varies. Prerequisite: Mus 20, or 81, or consent of the chairperson. Sine

133. History: Medieval and Renaissance Music (3) fall, odd-numbered years
Development of musical style from early Christian chant to the sacred and secular forms of the late sixteenth century, viewed in cultural contexts. Mus 20 or 81. Sine

134. History: Baroque and Classical Music (3) spring, even numbered years
The major genres and composers of the 17th and 18th centuries studied in their cultural context. Prerequisite: Mus 20 or 81. Sine

137. History: Romantic Era (19th century) (3) fall, even numbered years
Study of the major composers and their works from late Beethoven to Mahler and Debussy. Prerequisite: Mus 20 or 81. Sine

138. History: Twentieth-Century Music (3) spring, odd-numbered years
Beginning with the major trends at the turn of the century, a study of the important composers and works of our century to the present. Prerequisite: Mus 20 or 81.

153. Electronic Music (3) fall
Components of an electronic studio introduced via a working relationship. Recording both live and electronic sounds, realizing a portion of score for electronic sound, constructing tape loops having particular characteristics, and preparing a final work of taped sounds. Prerequisite: consent of the department chairperson. Salerni

154. Electronic Music (3) spring
Continuation of Mus 153. Prerequisite: Mus 153. Salerni

212. Theory II: Counterpoint (4) spring, odd-numbered years
Writing and analyzing pieces in Renaissance and Baroque contrapuntal styles. Ear training and keyboard skills. Prerequisite: Mus 111.

213. Theory III: Form and Analysis (4) spring, even-numbered years
Analyzing and writing pieces in classical and romantic forms. Exercises in chromatic harmony. Ear training and keyboard skills. Prerequisite: Mus 111.

220. Composition (3) spring
Applications of the principles of Mus 81 and 111 to compositional practice. Prerequisite: Mus 111, or equivalent, or consent of the department chairperson. Salerni

251. Special Topics (1-3)
Study of musical topics or work in musical history or composition not covered in regular courses, or continuation of study of topics or of projects in composition or history begun in regular courses. May be repeated for credit. Prerequisite: consent of the department chairperson.

Natural Science

Charles B. Sclar, Ph.D. (Yale), *director,* natural science program.

This major program provides students with a broad background in the fundamentals of mathematics and science and the opportunity to concentrate to a reasonable extent in one area of science.

The program leads to a Bachelor of Arts degree and is designed especially for the following: 1. those students who want preparation for graduate work or careers in certain of the derivative or interdisciplinary sciences or related professional fields (oceanography, astronomy, psycho-physiology, medicine or dentistry, etc.); 2. those students who plan to teach in secondary schools or community colleges; and 3. those students without fixed career objectives who want undergraduate training in science.

Students who register for the program are required to select an area of concentration (or option) that must be approved by the dean of the College of Arts and Science and the director of the program. The option may be chosen in chemistry, biology, geology, psychology, or in an approved interdisciplinary area (biophysics, marine science, biochemistry, computer science, etc.). Courses included in the option are worked out individually for the student by the major adviser.

Qualified students may be given permission at the end of the junior year to enter a program whereby they are able to begin work toward a graduate degree (master of arts, master of science, or master of education) during the senior year. Students enrolled in this program often complete all course requirements for the master's degree with one year of study beyond the bachelor's degree.

required preliminary courses

Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12)
Phys 11, 12	Introductory Physics I and Laboratory I (5)
Phys 21, 22	Introductory Physics II and Laboratory II (5) **or**
Phys 13, 14	General Physics and Laboratory (4)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
Geol 21, 22	Principles of Geology and Introductory Geology Laboratory (4) **or**
Astr 1	The Solar System (3)
Biol 21, 22	Principles of Biology and Introduction to Laboratory (4) **or**
Psyc 1	Introduction to Psychology (3)

required major courses

Chem 51, 52	Organic Chemistry (6) **and**
Chem 53, 54	Organic Chemistry Laboratory (3) **or**
Chem 31	Chemical Equilibria in Aqueous Systems (3) **and**
Chem 187	Physical Chemistry I (3)
Math	elective (3)
	option (24)

Note: The mathematics elective and courses included in the option are taken with approval of the major adviser.

Students registered for this major normally are expected to choose their option no later than the second semester of the sophomore year.

Philosophy

Professors. J. Ralph Lindgren, Ph.D. (Marquette), *William Wilson Selfridge Professor of Philosophy;* Robert F. Barnes, Jr., Ph.D. (Berkeley); Steven Louis Goldman, Ph.D. (Boston), *Andrew W. Mellon Distinguished Professor in the Humanities and director of the Science, Technology and Society program;* Norman P. Melchert, Ph.D. (Pennsylvania).
Associate professor. John E. Hare, Ph.D. (Princeton), *chairperson.*
Assistant professor. Gordon Bearn, Ph.D. (Yale).

The study of philosophy does several things for a student. It improves certain skills, such as the ability to analyze and evaluate arguments, to identify faulty reasoning and to reason well, and to read and understand a difficult and complex text. It provides an acquaintance with the great works in philosophy which have helped form our culture. It teaches what our contemporaries are thinking, for example, about whether moral and aesthetic standards are objective, or when the claims to have knowledge can be justified, or how the mind is related to the brain. It identifies the important philosophical issues raised by areas of human activity such as medicine, business, religion, science and the law. Students of philosophy are studying some of the most important foundations of their view of themselves and their world.

The major program is substantial enough to prepare a student for subsequent graduate study. There is also a wide variety of courses of general interest to students from all three

undergraduate colleges. The program has the flexibility to supplement the major with coursework relevant to a variety of careers. Some of our majors have gone directly into banking, communications, insurance, marketing and publishing, immediately after graduation. Others, after graduate or professional school, went into academic philosophy, law, medicine, urban planning, and corporate management.

The philosophy faculty emphasizes interaction with students. Students participate with faculty members in "reading parties" each spring—retreats where students and faculty read and discuss ideas together for a few days. They attend lectures by distinguished philosophers who visit the campus two to three times each semester and participate in discussions with students. They join the Philosophy Club which brings students and faculty together in small group activity once a week.

Department honors are awarded on the basis of a thesis or a disputation (a public defense of a philosophical thesis or theses) supervised by one or more members of the department, and the attainment of a cumulative average for all courses in philosophy of 3.25 or better at the time of graduation.

The Minor Program

The minor in philosophy consists of fifteen credit hours of course work. The specific courses to be taken by a student in this program are decided jointly by the student and the departmental adviser. These ordinarily include at least one course at the introductory level and one at the advanced level. Minor programs may be either of a general character or organized around a special theme such as: the philosophy of science, logic, ethics and value theory, the history of philosophy, and social philosophy.

The Major Program

The major in philosophy consists of thirty credit hours of course work. The specific courses to be taken are decided jointly by the student and the departmental adviser. All major programs include the following:

Phil 14	Foundations of Logic (3)
Phil 131	Ancient Philosophy (3)

plus two of the following:

Phil 2	The Great Conversation II (3)
Phil 133	Medieval Philosophy (3)
Phil 135	Modern Philosophy (3)
Phil 139	Contemporary Philosophy (3)
Phil 237	Kierkegaard and Nietzsche (3)

plus three of the following:

Phil 128	Philosophy of Science (3)
Phil 214	Logical Theory (3)
Phil 215	Contemporary Ethics (3)
Phil 220	Knowledge and Justification (3)
Phil 250	The Minds of Men and Robots (3)
Phil 251	Action, Free Will, and Fate (3)

plus

Phil 291	Seminar (3)

An additional six credit hours is selected with the counsel and approval of the departmental adviser. At least three of these six hours are to be from courses at the 100 level or above. Phil 221 does not count toward the major. At the discretion of the department, a major may be required to take and pass Engl 71, Expository Writing Workshop.

Undergraduate Courses

1. The Great Conversation I (3) fall
An introduction to philosophy by way of its history. The development of ideas about the real, the true, and the good in ancient and medieval times. Special attention to Plato, Aristotle, and Augustine. (May be taken independently of Phil 2). Melchert

2. The Great Conversation II (3) spring
An introduction to philosophy by way of its history. The struggle for wisdom since the development of modern science. What we can know, what we should do, and what kind of beings we are. (May be taken independently of Phil 1). Melchert

10. Introduction to Philosophy (3) fall-spring
Basic philosophical questions, perennial and contemporary, such as the objectivity of morals, the justification of government, the place of mind and feeling in the world of matter and energy, the nature of knowledge and truth, and the reality of God.

13. Practical Logic (3) fall
Reaching conclusions and justifying conclusions-two kinds of reasoning. The role of logic in problem solving and decision-making processes. Comparison of deductive and inductive reasoning and justification. Practice in analysis, criticism, evaluation and construction of arguments. Emphasis on developing practical ability, with material drawn from real-life contexts. Barnes

14. Foundations of Logic (3) spring
The development of several symbolic languages as theoretical models for explaining certain logical features of ordinary English discourse, such as valid inference and necessary truth. Some significant general properties of these symbolic languages are studied.

15. Ethics (3) fall-spring
Development of the ability to thoughtfully formulate one's own moral orientation and to understand those of others through a critical study of major ethical theories such as rationalism, formalism, utilitarianism, and existentialism. Special attention is directed to such topics as moral character, judgment and responsibility.

114. (MS 114) War, Morality, Ethics and Military Professionalism (3) spring
Development of the Profession of Arms, its fundamental values and institutions. Ethical responsibilities of military professionals in contemporary American society. Moral dimensions of war, just war theory and international law of war. Prerequisite: consent of department chairperson. Hare

115. Business Ethics (3) spring
Special problems in moral responsibility and ethical theory relating to contemporary business institutions, due to new dimensions of knowledge and evaluation, and emerging techniques of decision-making, planning, and management that characterize those institutions.

116. Medical Ethics (3) spring
Contemporary moral problems encountered in the practice of medicine examined in the light of ethical theories of the nature and foundation of rights and moral obligations. Abortion, euthanasia, genetic engineering, the nature of informed consent, the distribution of health care, etc. Volpe

122. Philosophy of Law (3) spring
Analysis of the conceptual foundations of our legal system. Special attention is devoted to the nature and validity of law, the relation of law and morality in the judicial decision, the concepts of liberty and justice in constitutional litigation, the theories of punishment in criminal law, and the nature and scope of responsibility in criminal and tort law. Lindgren

123. Aesthetics (3) spring
Theories, classical and modern, of the nature of beauty and the aesthetic experience. Practical criticism of some works of art, and examination of analogies between arts, and between art and nature. Hare

124. (Rel 124) Reason and Religious Experience (3) spring
A critical look at some of the fundamental problems of religion: the nature of religious experience and belief, reason

and revelation, the existence and nature of God, the problem of evil, and religious truth. Hare

128. Philosophy of Science (3) fall
Introduction to the structure and methods of scientific investigation. The nature of explanation, confirmation, and falsification. Scientific progress: What is it? Would it be suffocated by obedience to completely rational methods?

131. (Clss 131) Ancient Philosophy (3) fall
Historical study of philosophy in the classical world from the pre-Socratics to Plato, Aristotle, and the Neo-Platonists, as the originators of the western tradition in philosophy and as interacting with the religious, political and scientific life of their times. Hare

133. Medieval Philosophy (3) spring
Historical study of philosophy from the Roman Empire to the Renaissance. Attention to Islamic, Jewish, and Christian traditions and their interaction with the scientific and cultural life of the period.

135. Modern Philosophy (3)
Philosophers from the Renaissance to the mid-19th century. Descartes, Locke, Hume, Rousseau, Kant and Hegel. Their interaction with political, scientific, and religious thought of the period.

139. Contemporary Philosophy (3)
Philosophical thought from the mid-19th century to the present; pragmatism, linguistic analysis, existentialism, and Marxism. Truth and knowledge, values and moral judgment, meaning, and place of the individual in the physical world and society, and the impact of scientific method upon all of these. Melchert

214. Logical Theory (3)
Conceptual foundations and philosophical significance of classical and modern logical theories. Analysis of the syntactic and semantic methods in logic, and their interrelations. Philosophical impact of important technical results, including Goedel's incompleteness theorem. Some discussion of potential future developments and alternative logics. Prerequisite: Phil 14 or consent of the department chairperson. Barnes

215. Contemporary Ethics (3) fall
Recent literature on problems in theoretical ethics. Prerequisite: Phil 15 or consent of the department chairperson.

220. Knowledge and Justification (3)
Extent and sources of knowledge, whether knowledge requires certainty, and how beliefs about the world are justified.

221. (Law 221) Sex-Discrimination and the Law (3) fall
A critical study of the law of sex-discrimination in areas of constitutional and labor law. A case approach that places special emphasis on the rights of employees and the obligations of employers. Topics include equal protection, equal employment opportunity, and affirmative action. Lindgren

224. (Rel 224) Topics in the Philosophy of Religion (3)
Selected problems and issues in the philosophy of religion. May be repeated for credit as the subject matter varies.

228. Topics in the Philosophy of Science (3)
Themes in the natural, life and social sciences. May be repeated for credit as topic varies. Goldman

237. (Rel 237) Kierkegaard and Nietzsche (3) spring
Two maverick thinkers of the 19th century, concerned with religious faith, values, and the meaning of human existence. Melchert

250. The Minds of Men and Robots (3) fall
Is the nature of thinking illuminated by what computers can do? Is the brain just a complex computer? Could a robot feel pain? Be angry? Recent work in artificial intelligence, psychology, and philosophy. Melchert

251. Action, Free Will, and Fate (3) spring
Are we free to act as we choose? Are we free to choose? The concept of action: intentions and actions, reasons and causes, and whether there can be deterministic explanations of actions. Melchert

271. Readings in Philosophy (1-3)
A course in readings designed primarily for the undergraduate philosophy majors and minors and graduate students in other disciplines. Prerequisite: consent of the department chairperson.

272. Readings in Philosophy (1-3)
A course of readings designed primarily for undergraduate philosophy majors and minors and graduate students in other disciplines. Prerequisite: consent of the department chairperson.

291. Seminar (3)
Examination of selected topics for philosophy majors and minors and other advanced students.

Physics

Professors. Yong W. Kim, Ph.D. (Michigan), *chairperson;* Garold J. Borse, Ph.D. (Virginia); Raymond J. Emrich, Ph.D. (Princeton); Frank J. Feigl, Ph.D. (Pittsburgh); Robert T. Folk, Ph.D. (Lehigh); W. Beall Fowler, Ph.D. (Rochester); Alvin S. Kanofsky, Ph.D. (Pennsylvania); James A. McLennan, Ph.D. (Lehigh); Shelden H. Radin, Ph.D. (Yale); Wesley R. Smith, Ph.D. (Princeton); George D. Watkins, Ph.D. (Harvard), *Sherman Fairchild Professor of Solid-State Studies.*
Associate professors. Brent W. Benson, Ph.D. (Penn State); Gary G. DeLeo, Ph.D. (Connecticut); Russell A. Shaffer, Ph.D. (Johns Hopkins).
Assistant professors. Kurt H. Becker, Ph.D. (Universität des Saarlandes); John P. Huennekens, Ph.D. (Colorado); Ricardo Pakula, Ph.D. (Münich); Jean Toulouse, Ph.D., (Columbia).

Effective July 1, 1987, the department of physics, traditionally associated with the College of Engineering, will be administered within the College of Arts and Science. Because the change is primarily related to the university's organization, students enrolled in existing physics degree programs will not be affected in their course work.

Students may major in physics and earn a bachelor of science in engineering physics in the College of Engineering and Applied Science or major in physics in the College of Arts and Science and earn a bachelor of arts degree.

The engineering physics curriculum requires somewhat more physics and mathematics than the bachelor of arts major, while the latter requires more courses in the humanities, social sciences, and foreign languages or cultures. By proper choice of electives, either program can prepare a student for graduate work in physics. Because of the large number of approved and free electives, an engineering physics student can prepare for graduate work in physics or the physical aspects of other sciences or engineering disciplines, or can prepare for technical careers requiring a basic knowledge of physics. The bachelor of arts curriculum is particularly useful for those planning careers in areas where knowledge of physics is needed or useful, but is not the main subject, such as science writing, secondary school teaching, patent law, or medicine.

A comparison of the two curricula in terms of credit hours in various broad categories is given below.

	B.S. in engineering physics	B.A. major in physics
Freshman English	6	6
distribution courses (not including mathematics or science)	19	32 to 40 (depending on language requirements)
Required preliminary and major courses	68	60
approved electives	14	11
electives	17	3 to 11
total	124	120

A student in physics studies the basic laws of mechanics, heat and thermodynamics, electricity and magnetism, optics, relativity, quantum mechanics, and elementary particles. The student also studies applications of the basic theories to the description of bulk matter, including the mechanical, electric, magnetic, and thermal properties of solids, liquids, gases, and plasmas, and to the description of the structure of atoms and nuclei. In addition, the student develops the laboratory skills and techniques of the experimental physicist, skills that can be applied in the experimental search for new knowledge or in applications of the known theories.

Because of the fundamental nature of physics, students may use the major to prepare for many different careers. With judicious choice of electives, the physics student can prepare for graduate work in physics, in applied mathematics, in computer science, or in allied sciences such as biophysics, molecular biology, astrophysics, geophysics, materials engineering, meterology, or physical oceanography. Further study toward careers in professional areas such as law or medicine is not uncommon.

In addition, the student may choose electives that prepare him or her for graduate work in those areas of engineering that have a high science content such as: aeronautical engineering; nuclear engineering, including both fission and fusion devices; electrical engineering, including instrumentation, electronics, and solid-state devices, electrical discharges and other plasma-related areas; and mechanical engineering and mechanics, including fluids and continuum mechanics. Graduate work in any of these areas can prepare the student for a career in industrial research or development, or in university or college teaching and research.

The student who plans on employment immediately after the bachelor's degree may choose electives that develop the skills needed for a position in a particular area. For example, with judicious choices of electrical engineering and physics courses in electronics and solid-state physics, a strong applied background can be developed for employment in solid-state electronics. If the student chooses applied mathematics courses and computer courses to supplement the physics courses, a strong preparation can be achieved for employment in the many areas that use numerical methods in analysis and development.

Many other specialties may be developed by the student by appropriate use of electives so that the bachelor-degree student can offer an employer the advantages of a broad and fundamental science background combined with a significant concentration in a particular area of science, engineering, or applied mathematics.

Students are advised that admission to graduate school requires a minimum grade average, with a minimum average of B being typical. Also, some graduate schools require a reading knowledge of a modern foreign language.

Physics Major in Arts and Science

required preliminary courses

Chem 21, 22	Introductory Chemical Principles and Chemical Principles Laboratory (5)
Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Phys 21, 22	Introductory Physics II and Laboratory (5)

required major courses

Phys 31	Introduction to Quantum Mechanics (3)
Phys 171	Physics Proseminar (1)
Phys 190	Electronics (3)
Phys 212	Electricity and Magnetism I (3)
Phys 213	Electricity and Magnetism II (3)
Phys 215	Classical Mechanics I (3)
Phys 260	Laboratory Techniques (2) **or**
Phys 261	Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phys 264	Nuclear and Elementary Particle Physics (3)
Phys 340	Thermal Physics (3)
Phys 362	Atomic and Molecular Structure (3)
Math 205	Linear Methods (3)
Math 322	Methods of Applied Analysis I (3)
	approved science, mathematics, or technical electives (11)

The engineering physics curriculum below may serve as a useful guide in designing the sequence for the bachelor of arts physics major.

Engineering Physics in Engineering and Applied Science

freshman year (see page 36)

sophomore year, first semester (16 credits)

Phys 21, 22	Introductory Physics II and Laboratory (5)
Math 23	Analytic Geometry and Calculus III (4)
	elective (3)
Eco 1	Economics (4)

sophomore year, second semester (15)

Phys 31	Introduction to Quantum Mechanics (3)
Phys 190	Electronics (3)
Math 205	Linear Methods (3)
	General Studies requirement (3)
	electives (3)

junior year, first semester (17)

Phys 212	Electricity and Magnetism I (3)
Phys 215	Classical Mechanics I (3)
Phys 260	Laboratory Techniques (2)
Math 322	Methods of Applied Analysis I (3)
	electives (6)

junior year, second semester (17)

Phys 213	Electricity and Magnetism II (3)
Phys 261	Optics, Spectroscopy, and Quantum Physics Laboratory (2)
Phys 362	Atomic and Molecular Structure (3)
Phys 264	Nuclear and Elementary Particle Physics (3)
	General Studies requirement (3)
	electives (3)

senior year, first semester (17)

Phys 216	Classical Mechanics II (3)
Phys 340	Thermal Physics (3)
	General Studies requirement (3)
	electives (8)

senior year, second semester (15)

Phys 171	Physics Proseminar (1)
	General Studies requirement (3)
	electives (11)

The electives include at least fourteen credit hours of approved technical electives, including two of the courses Phys 363, 367, 369, 352 or 355, and 346 or 348 or 365. Students planning graduate work in physics are advised to include Phys 273 and 369 among their electives. Up to 6 credit hours of the following courses may be included as part of the 127 credit hours

required for graduation: Aerospace Studies, Jour 1-10, Military Science, and Mus 21-78.

Special opportunities. A majority of physics and engincering physics majors take advantage of opportunities to participate in research under the direction of a faculty member. Research areas available to undergraduates are the same as those available to graduate students; they are described below under the heading For Graduate Students. Undergraduate student research is arranged informally as early as the sophomore (or, occasionally, freshman) year at the initiation of the student or formally as a senior research project. In addition, a number of students receive financial support to do research during the summer between their junior and senior years, either as Physics Department Summer Research Participants or as Sherman Fairchild Scholars.

The use of electives. The electives provided in both physics curricula provide the student with an oppotunity to develop special interests and to prepare for graduate work in various allied areas. The student is urged to reflect upon how to take advantage of this opportunity. A student contemplating graduate work in physics should consider the many upper-level physics and mathematics courses available, as well as some of the beginning graduate courses. In addition, note that some graduate schools require a reading knowledge of a modern foreign language.

Students contemplating using electives to develop a special area of interest should try to plan such a program as soon as possible by consultation with members of the faculty. Since many possibilities exist, it is impractical to list all such programs. Instead, two such programs are listed below to serve as guides for those with interests in those areas and to serve as models for those interested in developing their own programs in other areas.

Biophysics

Biol 21	Principles of Biology (3)
Biol 28	Mendelian and Population Genetics (3)
Biol 220	Cell Physiology (3)
Biol 235	Microbiology (3)
Biol 345	Molecular Genetics (3)
Chem 51, 52	Organic Chemistry (6)
Chem 371	Elements of Biochemistry I (3)

Solid-State Electronics

Mat 93	Introduction to Solid State Materials (3)
ECE 125	Circuits and Systems (3)
ECE 126	Physical Electronics (3)
ECE 123	Electronic Circuits (3)
ECE 308	Electronic Device Modeling Theories (3)
ECE 351	Microelectronics (3)
Phys 363	Physics of Solids (3)

Undergraduate Courses in Physics

9. Introductory Heat and Thermodynamics (1) fall-spring
Temperature, heat, and the laws of thermodynamics; kinetic theory of gases. The student will be scheduled for the appropriate part of Phys 11. Prerequisites: three credit hours of advanced placement, anticipatory exam, or transfer credit for the mechanics part of Phys 11, and consent of the chairman of the department.

11. Introductory Physics I (4) fall-spring
Kinematics, frames of reference, laws of motion in Newtonian theory and in special relativity, conservation laws, as applied to the mechanics of mass points; temperature, heat and the laws of thermodynamics; kinetic theory of gases. Two lectures and two recitations per week. Prerequisite: Math 21, 31 or 41, previously or concurrently. Borse or Fowler

12. Introductory Physics Laboratory I (1) fall-spring
A laboratory course taken concurrently with Phys 11. Experiments in mechanics, heat, and DC electrical circuits. One three-hour laboratory period per week.

13. General Physics (3) spring
A continuation of Phys 11, primarily for students in the College of Arts and Science and premedical students. Electrostatics, electromagnetism, light, atomic physics, nuclear physics and radioactivity, introduction to biophysics. Prerequisite: Phys 11 and Math 21, 31 or 41. Smith

14. General Physics Laboratory (1) spring
A laboratory course to be taken concurrently with Phys 13. Prerequisite: Phys 12; Phys 13, preferably concurrently.

19. Introductory Optics and Modern Physics (1) fall-spring
Physical and geometrical optics; introduction to modern physics. The student will be scheduled for the appropriate part of Phys 21. Prerequisites: three credit hours of advanced placement, anticipatory exam, or transfer credit for the electricity and magnetism part of Phys 21, and consent of the chairman of the department.

21. Introductory Physics II (4) fall-spring
A continuation of Phys 11. Electrostatics and magnetostatics; DC circuits; Maxwell's equations; waves; physical and geometrical optics; introduction to modern physics. Two lectures and two recitations per week. Prerequisite: Phys 11; Math 23, 32, or 44, previously or concurrently. DeLeo or McLennan

22. Introductory Physics Laboratory II (1) fall-spring
A laboratory course to be taken concurretly with Phys 21. One three-hour laboratory period per week. Prerequisite: Phys 12; Phys 21, preferably concurrently.

31. Introduction to Quantum Mechanics (3) fall-spring
Experimental basis and historial development of quantum mechanics; the Schroedinger equation; one-dimensional problems; angular momentum and the hydrogen atom; many-electron systems; spectra; selected applications. Three lectures per week. Prerequisite: Phys 13 or 21; Math 205, previously or concurrently. Feigl, Toulouse, Watkins

42. Physics for Poets (3) spring
The principal concepts and discoveries of physics from Newton's laws through quantum mechanics and elementary particles are presented in a concise manner. The relevance of physics to modern society is also discussed. The laboratory provides direct exposure to modern technological devices such as integrated circuits and computers, and it also serves to demonstrate the concepts covered in lectures. The purpose of the course is to provide students majoring in subjects other than science and engineering with sufficient background to enable them to cope with, appreciate, and understand the science and technology of modern society. High school physics is not assumed. Two recitation periods and one laboratory period per week. No prerequisite. Borse

171. Physics Proseminar (1) spring
Discussion of current problems in physics. Intended for seniors majoring in the field. Toulouse

190. Electronics (3) spring
DC and AC circuits, diodes, transistors, operational amplifiers, oscillators, and digital circuitry. Two laboratories and one recitation per week. Prerequisite: Phys 21 and 22, or Phys 13 and 14. Smith, Becker

For Advanced Undergraduates And Graduate Students

212. Electricity and Magnetism I (3) fall
Electrostatics, magnetostatics, and electromagnetic induction. Prerequisites: Phys 21 or 13; Math 205, previously or concurrently. Folk

213. Electricity and Magnetism II (3) spring
Maxwell's equations, Poynting's theorem, potentials, the wave equation, waves in vacuum and in materials, transmission and

reflection at boundaries, guided waves, dispersion, electromagnetic field of moving charges, radiation, Lorentz invariance and other symmetries of Maxwell's equations. Prerequisite: Phys 212. McLennan

215. Classical Mechanics I (3) fall
Kinematics and dynamics of point masses; force laws, including motion in a central force field, simple harmonic motion and non-linear oscillations; conservation laws; description of a system of particles, including collisions; moving coordinate systems and the special theory of relativity. Prerequisites: Phys 21 or Phys 13 and Math 205, previously or concurrently. Toulouse

216. Classical Mechanics II (3) fall
Continuation of Phys 215. Gravitation; rotating coordinate systems; motions of rigid bodies; Lagrange's and Hamilton's equations; continuum mechanics, including elasticity and fluid mechanics. Prerequisite: Phys 215. Radin

260. Laboratory Techniques (2) fall
Laboratory practice, including machine shop, vacuum systems, electronic instrumentation, computers and integrated circuits, high-voltage measurements, counting and statistics. Prerequisites: Phys 21 and 22, or Phys 13 and 14. Becker, Toulouse

261. Optics, Spectroscopy, and Quantum Physics Laboratory (2) spring
Experiments in geometrical optics, interference and diffraction, spectroscopy, lasers, and quantum phenomena. Prerequisites: Phys 21 and 22, or Phys 13 and 14. Huennekens

264. Nuclear and Elementary Particle Physics (3) spring
Models, properties, and classification of nuclei and elementary particles; nuclear and elementary particle reactions and decays; radiation and particle detectors; accelerators; applications. Prerequisites: Phys 31 and Math 205. Shaffer

273. Research (2-3) fall-spring
Participation in current research projects being carried out within the department. Intended for seniors majoring in the field. May be repeated once for credit.

281. Basic Physics I (3) summer
A course designed especially for secondary-school teachers in the master teacher program. Presupposing a background of two semesters of college mathematics through differential and integral calculus and of two semesters of college physics, the principles of physics are presented with emphasis on their fundamental nature rather than on their applications. Open only to secondary-school teachers and those planning to undertake teaching of secondary-school physics.

282. Basic Physics II (3) summer
Continuation of Phys 281.

312. Advanced Laboratory (1) fall-spring
Experiments in modern physics designed to introduce students to measuring techniques and phenomena of current interest. Prerequisite: senior or graduate standing in the field, or consent of the department chairperson. May be repeated for credit.

340. Thermal Physics (3) fall
Basic principles of thermodynamics, kinetic theory, and statistical mechanics, with emphasis on applications to classical and quantum mechanical physical systems. Prerequisites: Phys 13 or 21, and Math 23, 32 or 44. Benson

346. Physics of Developing Energy Sources (3) spring
Basic concepts, theoretical development, and experimental techniques pertaining to developing energy sources. Topics include thermonuclear, magnetohydrodnamic, solar and other potential sources of energy. Prerequisite: senior standing in the College of Engineering and Applied Sciences, or consent of the department chairperson.

348. Plasma Physics (3)
Single particle behavior in electric and magnetic fields, plasmas as fluids, waves in plasmas, transport properties, kinetic theory of plasmas, controlled thermonuclear fusion devices. Prerequisites: Phys 21, Math 205, and senior standing or consent of the chairman of the department. Pakula

352. Modern Optics (3) spring
Paraxial optics, wave and vectorial theory of light, coherence and interference, diffraction, crystal optics, and lasers. Prerequisites: Math 205, and Phys 212 or ECE 202. DeLeo

355. Lasers and Non-linear Optics (3) fall
Basic principles and selected applications of lasers and non-linear optics. Topics include electromagnetic theory of optical beams, optical resonators, laser oscillation, non-linear interaction of radiation with atomic systems, electro- and acousto-optics, optical noise, optical waveguides, and laser devices. Prerequisite: Phys 31; Phys 213 or ECE 203, previously or concurrently. Kim

362. Atomic and Molecular Structure (3) spring
Review of quantum mechanical treatment of one-electron atoms, electron spin and fine structure, multi-electron atoms, Pauli principle, Zeeman and Stark effects, hyperfine structure, structure and spectra of simple molecules. Prerequisite: Phys 31 or Chem 341. Becker

363. Physics of Solids (3) fall
Introduction to the theory of solids with particular reference to the physics of metals and semiconductors. Prerequisite: Phys 31 or Mat 316 or Chem 341.

365. Physics of Fluids (3) spring
Concepts of fluid dynamics; continuum and molecular approaches; waves, shocks and nozzle flows; nature of turbulence; experimental methods of study. Prerequisites: Phys 212 or ECE 202, and Phys 340 or ME 104 or equivalent, previously or concurrently. Emrich

369. Quantum Mechanics I (3) fall
Principles of quantum mechanics: Schroedinger, Heisenberg, and Dirac formulations. Applications to simple problems. Prerequisites: Phys 31, Math 205; Phys 216, previously or concurrently. Watkins

372. Special Topics in Physics (1-3)
Special topics in physics not sufficiently covered in the general courses. Lecture and recitations or conferences.

382. Applied Solid State Physics (3) spring
Applications of fundamental solid state physics to topics of current interest with emphasis on various physical effects and their use in practical applications. Topics include: effects of barriers and applied potentials on band structure (semiconductor junctions and interfaces), luminescence and photon absorption (solid-state lasers and radiation detectors), ferroelectricity and dielectric phenomena (electro-optical communication), superconductivity (Josephson and quantum interference devices). Prerequisite: Phys 363, or consent of the chairman of the department. Feigl

For Graduate Students

The department of physics has concentrated its research activities within several fields of physics, with the result that a number of projects are available in each area. Current departmental research activities include the following:

Solid-state physics (experimental). Optical and electronic properties of defects in semiconductors and insulators, electron paramagnetic resonance, ultrasonic attenuation, Raman spectroscopy, luminescence spectroscopy. Properties of thin films, physics of semiconductor devices.

Solid-state physics (theoretical). Electronic properties of defects in semiconductors and insulators, electronic structures, electron-lattice interactions, energy band calculations.

Atomic physics. Electron attachment. Optically assisted reactions. Collisional phenomena in alkali metal vapors. Dissociative collisions.

Plasma spectroscopy. Collisional and collisionless phenomena of very dense plasmas.

Nuclear theory. The few nucleon problem, nuclear structure theory.

Physics of fluids. Microscopic fluctuations in a flow. Shock-induced reactions in gases and phase transitions at liquid-vapor interfaces. Small particle dynamics.

Statistical physics (experimental). Non-equilibrium fluctuations in gases.

Statistical physics (theoretical). Kinetic theory, statistical basis of hydrodynamics, non-linear processes, bound states and internal degrees of freedom in kinetic theory.

Elementary particles (experimental). Fermilab and Brookhaven are used in channeling, device development, and particle jet studies.

Elementary particles (theoretical). Properties of leptons and vector bosons, weak and electromagnetic interactions. Quark-Glauber calculations of elastic and inelastic scattering.

Laser physics. Construction of gas lasers and studies of their characteristics; use of gas lasers in determination of oscillator strength and atomic parameters; mode structure; holography.

Van de Graaff studies. Experiments to study nuclear reactions, channeling, new instrumentation techniques, Rutherford back-scattering using the Lehigh van de Graaff accelerator.

Candidates for advanced degrees normally will have completed, before beginning their graduate studies, the requirements for a bachelor's degree with a major in physics, including advanced mathematics beyond differential and integral calculus. Students lacking the equivalent of this preparation will make up deficiencies in addition to taking the specified work for the degree sought.

Doctoral candidates may be required by their thesis committee to demonstrate a reading knowledge of one language, usually chosen from French, German or Russian. Some graduate work in mathematics is usually required; and certain advanced courses in other fields, notably mechanics, metallurgy and materials engineering, electrical engineering, and chemistry, may be included in a graduate program. Further details regarding the special requirements for degrees in physics may be obtained on application to the department chairperson.

At least eight semester hours of general college physics using calculus are required for admission to all 200- and 300-level courses. Additional prerequisites for individual courses are noted in the course descriptions. Admission to 400-level courses generally is predicated on satisfactory completion of corresponding courses in the 200- and 300-level groups or their equivalent.

Facilities for Research. The 1985-86 renovation and addition to the Physics Building has made available many new research laboratories and improved the quality of the older research space. It also expanded the shop area and provided a direct connection to the Sherman Fairchild Laboratory, where solid-state physics faculty and research space are located.

Among the research equipment available in the various experimental physics laboratories are: three electron spin resonance laboratories; a laboratory for optical detection of magnetic resonance; facilities for optical absorption and luminescence studies; ultraviolet, visible, and infrared spectrophotometers; liquid nitrogen, hydrogen, and helium cryogenic equipment; several shock tubes; film scanning apparatus; cosmic ray detectors; 9 high-power lasers (4 argon-ion lasers, 2 tunable pulsed dye lasers, a ruby laser, and 2 mode-locked, Q-switched Nd-glass lasers); crystal-growing facilities; a mass-spectrometer, large interferometers, an electron microscope, a high-density plasma source; electronic instrumentation for data acquisition and analysis, including several minicomputers, many microcomputers, and signal averagers; and an ultracentrifuge.

A 3 MeV Van de Graaff accelerator housed in the Sherman Fairchild Laboratory is used to study radiation defects in solids, to analyze impurity distributions in thin films, to develop instrumentation, and to study channeling and nuclear physics. Also available in materials and electrical engineering laboratories in the Fairchild Laboratory are excellent facilities for the preparation of solid-state materials and the fabrication of solid-state devices; these facilities are heavily used by physics students doing experimental solid-state research.

Graduate Courses in Physics

420. Theoretical Physics (3) fall
This and the three courses Phys 421, 422, and 423 cover the classical theory of particles and fields. Phys 420 includes the variational methods of classical mechanics, methods of Hamilton and Lagrange, canonical transformations, Hamilton-Jacobi theory. Fowler

421. Theoretical Physics (3) spring
Theory of elasticity; fluid dynamics; tensor analysis; electrostatics and magnetostatics. Prerequisite: Phys 420. Kim

422. Advanced Theoretical Physics (3) fall
Electromagnetic radiation; dynamics of charged particles; multipole fields; special theory of relativity and covariant formulation of electrodynamics. Prerequisite: Phys 421. Huennekens

423. Advanced Theoretical Physics (3)
Electrodynamics in anisotropic media; physical optics; theory of diffraction and application to holography; applications of electrodynamics. Prerequisite: Phys 422.

424. Quantum Mechanics II (3) spring
General principles of quantum theory; approximation methods; spectra; symmetry laws; theory of scattering. Prerequisite: Phys 369 or equivalent. Kanofsky

425. Quantum Mechanics III (3) fall, even-numbered years
A continuation of Phys 424. Relativistic quantum theory of the electron; theory of radiation. McLennan

428. Methods of Mathematical Physics (3) fall
The equations of theoretical physics and the methods of their solution. Folk

429. Methods of Mathematical Physics (3) spring
Continuation of Phys 428. Folk

431. Theory of Solids (3) spring, even-numbered years
Advanced topics in the theory of the electronic structure of solids. Many-electron theory. Theory of transport phenomena. Magnetic properties, optical properties. Superconductivity. Point imperfections. Prerequisite: Phys 363 and Phys 424. DeLeo

434. Solids and Radiation (3)
Phenomena in solids resulting from interaction with electromagnetic radiation or charged particles. Current theories of energy absorption, transport and emission. Prerequisite: Phys 363 or equivalent.

442. Statistical Mechanics (3) fall
General principles of statistical mechanics with application to thermodynamics and the equilibrium properties of matter. Prerequisite: Phys 340 and 369. Kim

443. Nonequilibrium Statistical Mechanics (3) spring, odd-numbered years
A continuation of Phys 442. Applications of kinetic theory and statistical mechanics to nonequilibrium processes; non-equilibrium thermodynamics. Prerequisite: Phys 442. McLennan

462. Theories of Elementary Particle Interactions (3)
Relativistic quantum theory with applications to the strong, electromagnetic and weak interactions of elementary particles. Prerequisite: Phys 425. Shaffer

465. Nuclear and Elementary Particle Physics (3) spring, even-numbered years
Nuclear structure and phenomena; interactions among elementary particles and methods of studying them. Kanofsky

467. Nuclear Theory (3) spring, odd numbered years
Theory of low-energy nuclear phenomena within the framework of nonrelativistic quantum mechanics. Borse

471. (Mech 411) Continuum Mechanics (3)
An introduction to the continuum theories of the mechanics of solids and fluids. This includes a discussion of the mechanical and thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of theories to specific problems are given. G. Smith, Varley

472. Special Topics in Physics (1-3)
Selected topics not sufficiently covered in the more general courses. May be repeated for credit.

474. Seminar in Modern Physics (3)
Discussion of important advances in experimental physics. May be repeated for credit when a different topic is offered.

475. Seminar in Modern Physics (3)
Discussion of important advances in theoretical physics. May be repeated for credit when a different topic is offered.

491. Research (3)
Research problems in experimental or theoretical physics.

492. Research (3)
Continuation of Phys 491. May be repeated for credit.

Portuguese

See listings under Modern Foreign Languages.

Psychology

Professors. Arthur L. Brody, Ph.D. (Indiana); Donald T. Campbell, Ph.D. (Berkeley), *University Professor of Social Relations and Psychology;* Martin L. Richter, Ph.D. (Indiana); George K. Shortess, Ph.D. (Brown).
Associate professors. William Newman, Ph.D. (Stanford), *chairperson;* John G. Nyby, Ph.D. (Texas, Austin).
Assistant professors. Diane T. Hyland, Ph.D. (Syracuse); Barbara C. Malt, Ph.D. (Stanford); Sandra L. Pipp, Ph.D. (Denver); Neal G. Simon, Ph.D. (Rutgers); S. Lloyd Williams, Ph.D. (Stanford).
Adjunct professors. Thomas O. Blank, Ph.D. (Columbia); Roy C. Herrenkohl, Ph.D. (N.Y.U.); Murray Itzkowitz, Ph.D. (Maryland); Edwin J. Kay, Ph.D. (Lehigh); Theophile Krawiec, Ph.D. (N.Y.U.); Artis J. Palmo, Ed.D. (West Virginia); John F. Riley, Ed.D. (Lehigh); Robert E. Rosenwein, Ph.D. (Michigan); Edward S. Shapiro, Ph.D. (Pittsburgh); Kurt Wallen, Ph.D. (Berkeley).
Visiting assistant professor. Mary B. Seay, Ph.D. (Lehigh).

Major Program in Psychology

The bachelor of arts in psychology is a social science major requiring a minimum of thirty credit hours in psychology as defined below. Second-semester freshmen who have completed Psych 1 or 11 can enroll in the 100-level courses by petition, and should check with the chairperson of the psychology department if interested.

Required Major Courses

Psyc 1	Introduction to Psychology (3) **or**
Psyc 11	Introduction to Psychology: Discussion Format (3) **and**
Psyc 110	Experimental Design and Statistical Analysis (3)
Psyc 210	Experimental Psychology (4)

Plus the following
one from each of the four categories

A) Psyc 107	Child Development (3)
Psyc 108	Adolescent Development (3)
Psyc 109	Adulthood and Aging (3)
B) Psyc 21	Social Psychology (3)
Psyc 154	Introduction to Clinical Psychology (3)
C) Psyc 117	Cognitive Psychology (3)
Psyc 171	Learning (3)
D) Psyc 176	Cognitive Neuroscience (3)
Psyc 177	Introduction to Physiological Psychology (3)

and at least four from

Psyc 305	Abnormal Psychology (3)
Psyc 307	Seminar in Cognition (3)
Psyc 331	Humanistic Psychology (3)
Psyc 351	Cognitive Development in Childhood (3)
Psyc 353	Personality Theory (3)
Psyc 354	Personality Assessment (3)
Psyc 361	Special Topics in Adult Development (3)
Psyc 363	Social and Personality Development (3)
Psyc 371	Theories of Learning (3)
Psyc 373	Sensation and Perception (3)
Psyc 375	Neuroanatomy of Behavior (3)
Psyc 382	Endocrinology of Behavior (3)

Concentration in Biopsychology

Psychology majors may elect to take the core required courses for the major (Psyc 1 or 11 and Psych 110 and 210) and then concentrate their psychology electives in life science related courses. These students will also be required to take additional biology, chemistry and mathematics courses to round out this curriculum.

The concentration in biopsychology is a natural science major for BA distribution purposes. Biopsychology is an interdisciplinary field drawing on psychology, biology, chemistry, and anthropology. This major examines the physiology, genetics, and evolution of behavior with an emphasis on the neurosciences.

Required Major Courses

Core Courses

Psyc 1	Introduction to Psychology (3) **or**
Psyc 11	Introduction to Psychology: Discussion Format (3)
Biol 21	Principles of Biology (3) **and**
Biol 22	Introduction to Biology Laboratory (1)
Anth 12	Emergence of Mankind and Culture (3)
Biol 28	Mendelian and Population Genetics (3)
Psyc 110	Experimental Design and Statistical Analysis (3)
Psyc 210	Experimental Psychology (4)
Psyc 177	Introduction to Physiological Psychology (3)

Category 1: take one course

Biol/Psyc 335	Animal Behavior (3)
Biol/Psyc 337	Sociobiology (3)

Category 2: take one course

Psyc/Biol 375	Neuroanatomy of Behavior (3)
Psyc 382/Biol 376	Endocrinology of Behavior (3)

Category 3: nine credits (major electives)

Psyc 77	Drugs and Behavior (3)
Psyc 176	Introduction to Cognitive Neuroscience (3)
Psyc 376	Physiological Psychology Laboratory (1)
Psyc 377	Seminar in Physiological Psychology (3)
Psyc 373	Sensation and Perception (3)
Psyc/SR 345	Seminar on the Social Evolution of Complex Organizations (3)

Biol 134	Comparative Vertebrate Anatomy (4)
Biol 151	Vertebrate Field Biolgy (3)
Biol 211	Ecology (3)
Biol 220	Cell Physiology (3)
Biol 223	Animal Physiology (3)
Biol 313	General Histology (3)
Biol 314	Developmental Biology (3)
Biol 319	Reproduction and Mating Systems (3)
Biol 329	Herpetology (3)

Required Course in Math and Chemistry

Math 41, 44	BMSS Calculus I and II (6) **or**
Math 21, 22	Analytic Geometry and Calculus I and II (8)
Chem 21	Introductory Chemical Principles (4)
Chem 22	Chemical Principles Laboratory (1)
Chem 51, 52	Organic Chemistry (6)
Chem 55	Organic Chemistry Laboratory (2)

Other Options

The concentration in biopsychology is a traditional liberal arts degree which can be structured for a wide variety of possibilities (see listing of recommended elective courses). By using free electives to take additional math and science, the B.A. also can serve as a preprofessional degree for many graduate and professional schools. Students interested in a particular career-based program should consult their advisor or the program director (Professor John Nyby).

Additional Required Courses. These fulfill College of Arts and Science distribution requirements. They are elective courses that bring the credit-hour total to 121.

Note: Psychology majors may not use psychology courses to satisfy upperclass college distribution requirements.

Recommended Electives

The bachelor of arts program in psychology is a flexible preparation for a number of fields. With a suitable selection of additional courses, students can prepare themselves for graduate study in clinical psychology, developmental psychology, social psychology, personality, or for careers in areas for which psychology is a desirable and relevant major, e.g., law, social work, nursing, or special education. Courses recommended, in addition to those major courses listed above are:

Psyc 161	Independent Research Seminar (1-3)
Psyc 162	Psychological Field Work (1-3)
Psyc 395, 396	Thesis (6)
Psyc 421, 422	Analysis and Design of Experiments (6) (by petition)
Math 41	BMSS Calculus I (3)
Biol 21	Principles of Biology (3)
Biol 28	Mendelian and Population Genetics (3)

With greater emphasis on mathematics and science, the program provides preparation for graduate study in experimental psychology, medicine or dentistry. In this case, additional recommended courses are:

Psyc 161	Independent Research Seminar (1-3)
Psyc 162	Psychological Field Work (1-3)
Psyc 374	Sensation and Perception Laboratory (1)
Psyc 376	Physiological Psychology Laboratory (1)
Psyc 395, 396	Thesis (6)
Psyc 421, 422	Analysis and Design of Experiments (6) (by petition)
Math 21, 22, 23	Analytic Geometry and Calculus I, II and III (12) **or**
Math 31, 32	Honors Calculus I and II (8) **or**
Math 41, 42, 43, 44	BMSS Calculus I, Probability, Linear Algebra and Calculus II (12)
Biol 21, 22	Principles of Biology and Laboratory (4)
Chem 21, 22	Introductory Chemical Principles and Laboratory (5)
CSc 11	Introduction to Structured Programming (3)
CSc 17	Structured Programming and Data Structures (4)
Phys 11, 12	Introductory Physics I and Laboratory (5)
Phil 128	Philosophy of Science (3)

plus additional electives in mathematics, probability, statistics, computing and information science, biology, chemistry, and physics.

All students planning to pursue graduate study in psychology should take:

Psyc 395, 396	Thesis (6)

Of particular interest to those students interested in a career in business administration is the five-year Arts B.A.-M.B.A. degree. In this option, a student majors in psychology, takes requisite courses in the College of Business and Economics, and then takes an additional year of study in business administration beyond the bachelor's degree. The Arts B.A.-M.B.A. program is described in Section III. There are, of course, many other possibilities. Students interested in formulating a particular career-based program of study should consult the department chairperson.

Honors Program in Psychology

The honors program in psychology permits psychology majors of unusual academic ability and interest to explore areas of psychology in greater depth than the curricula normally allow. Under faculty supervision, a student normally spends the first semester of the senior year doing library research, learning the appropriate methodology, and preparing a written proposal. In the second semester the proposal is implemented, culminating in a written honors thesis. Successful completion of this program results in "Departmental Honors" being affixed to the student's transcript.

Eligibility requirements. Eligible students must be psychology majors; have completed the first semester of the junior year with an over-all GPA of 3.0; and have completed a minimum of four psychology courses in a grade-point average (GPA) of 3.3.

Interested students should contact the chairperson.

The Psychology Minor

The psychology minor consists of fifteen credit hours in psychology beyond the introductory course (Psych 1, 21). At least one of these courses must be above the 200 level. The student should consult the department chairperson no later than the fifth semester regarding course selection.

Undergraduate Courses

The entry NS or SS applies only to psychology courses and refers to Natural Science or Social Science distribution requirements. Note: Psychology majors may *not* use SS or NS psychology courses to satisfy the upper level social science or natural science distribution requirement. Some listings also state the semester in which the course is customarily offered.

1. Introduction to Psychology (3) NS SS fall-spring
Psychology as a science of behavior. Natural science aspects such as learning, sensation-perception, and physiological bases; and social science aspects such as human developement, intelligence, and personality. Methodologies appropriate to these areas, and related societal problems.

11. Introduction to Psychology: Discussion Format (3) NS SS fall-spring
Identical in content to Psych 1 but classes are kept small.

21. (SPsy 21) Social Psychology (3) SS
Theories, methods of investigation, and results of research in social psychology with emphasis on psychological processes in

social behavior, social attitudes, group behavior, and social interaction. Not offered to students who have had Soc Psych 7.

31. Normal and Altered States of Consciousness (3) SS
Normal and altered states of consciousness are defined. These include waking, sleep, meditation, madness, and drug states. Newman

65. (Art 65) Perception and the Visual Arts (3) NS
Perceptual and cognitive theories and principles as related to visual fine arts and aesthetic experience. Shortess

77. Drugs and Behavior (3) SS
Basic principles of drug action in the central nervous system. Effects of stimulants, depressants, intoxicants and drug abuse on behavioral function. Clinical use of drugs in the treatment of various psychological and psychiatric disorders. Simon

81. Psychology and Law (3) SS spring
Problems with the concepts of insanity, psychosis, and therapy; commitment procedures, incompetency, and the insanity defense; patient's rights; psychological tests, discrimination and privacy; school and family law problems; and the expert witness and confidentiality. Brody

107. Child Development (3) SS
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. Prerequisite: Psyc 1 or 11. Pipp

108. Adolescent Development (3) SS spring
Descriptions and explanations of cognitive, personality, and physical development during the adolescent and early adult years. The stresses of adolescence and the difficulties that individuals enounter in their initial attempts to function as adults. Prerequisite: Psyc 1 or 11. Pipp

109. (SPsy 109) Adulthood and Aging: Social and Psychological Perspectives (3) SS
Psychological, sociological and other social science approaches to the latter two-thirds of the life span. Age stratification and distribution patterns, attitudes of aging, social behavior of older adults, widowhod, issues of retirement and use of leisure time. Blank, Hyland

110. Experimental Design and Statistical Analysis (3) NS spring
Principles of experimental design and statistical analysis: characteristics of data and data collection; descriptive statistics; hypothesis testing theory and practice; correlation, chi-square, t-test, analysis of variance. Richter

115. History of Modern Psychology (3) SS spring
Origin and development of major theories within perception, cognition, biological, clinical, personality, developmental, learning. Nineteenth and twentieth century thought to provide an overview of psychology as a discipline. Prerequisite: Psyc 1 or 11 or consent of the department chairperson.

117. Cognitive Psychology (3) NS
Information processing by human beings: attention, memory, language, and thought processes. Prerequisite: Psyc 1 or 11. Malt

121. Encountering Self and Others (3) SS fall-spring
An experientially oriented course to facilitate personal growth and develop a fuller awareness of personal functioning and interpersonal perception and communication. Pass-fail grading. Prerequisite: consent of the department chairperson. Newman

131. Psychology of Women (3) SS fall
Biological, cross-cultural, sociological and psychological perspectives on women, with reference to personal experience where appropriate. Prerequisite: Psyc 1 or 11 or an introductory social relations course, and consent of the department chairperson. Hyland

154. Introduction to Clinical Psychology (3) SS spring
Therapeutic approaches and their theoretical foundations: Psychoanalysis, client-centered, Gestalt, rational-emotive, behavioral, and existential therapies. This is not a how-to-do-it course in psychotherapy. Prerequisite: Psyc 1 or 11. Williams

160. Independent Study (1-3) NS SS fall-spring
Readings on topics selected in consultation with a staff member. Prerequisite: Psyc 1 or 11 and consent of the department chairperson. May be repeated for credit. Fulfills natural science or social science distribution requirements for students in the College of Arts and Science by petition only.

161. Independent Research Seminar (1-3) NS SS fall-spring
Individual research projects are designed and executed in close collaboration with the faculty. Students meet with the seminar director to communicate about and critique each other's projects. Prerequisite: Psyc 114 and consent of the department chairperson. May be repeated for credit. Fulfills NS or SS distribution requirements for students in the College of Arts and Science by petition only.

162. Psychological Field Work (1-3) SS fall-spring
Work-Study practice including supervised experience in one of several local agencies. Development of familiarity with the operations of the agency and working with individual patients or students. Prerequisite: Psyc 1 or 11 plus two additional psychology courses and consent of instructor.

171. Learning Processes and Applications (3) NS fall
Experimental data on animal and human conditioning and learning. Applications to mental health, mental retardation, education. Prerequisite: Psyc 1 or 11. Brody, Richter

176. Introduction to Cognitive Neuroscience (3) NS
Neurophysiological correlates of human cognitive and emotional processes such as imaging, dreams, hallucinations, attention, memory and language. Emphasis on cerebral lateralization, sleep and effects of brain damage on mental processes. Prerequisite: Psyc 1 or 11. Shortess

177. Introduction to Physiological Psychology (3) NS
Nervous system functioning with varying emphasis on neurophysiology, neuroanatomy, behavior genetics, information transmission, research techniques, sensory and motor functions. Prerequisite: Psyc 1 or 11 or Biol 1 or 21. Shortess, Nyby, Simon

201. Industrial Psychology (3) SS spring
Psychological concepts and methods applied to business and industrial settings. Personnel selection, placement and training, leadership, work motivation, job satisfaction and consumer behavior. Prerequisite: Psyc 1 or 11.

210. Experimental Psychology (4) NS fall
Data collection and research methods in various areas of psychology with humans and other animals. Laboratory exercises, report writing and an independent research project. Prerequisites: Psyc 1 or 11 and 2 other psychology courses. Richter

305. Abnormal Psychology (3) SS fall
The patterns, causes, and treatment of various forms of abnormal behavior. Supplemented by sessions at Allentown State Hospital. Prerequisite: Psyc 1 or 11, and three additional hours of psychology or consent of the department chairperson. Williams

307. Seminar in Cognition (3) NS
Topic varies from year to year. In-depth examination of selected topics in cognitive psychology, e.g., concept learning, decision making, social cognition. Prerequisite: Psyc 117 or consent of instructor. Malt

320. (CSc 310, Educ 320) Psycholinguistics (3) spring
Study of the experimental and observational literature on psychological processes involved in the production,

comprehension, and use of language by adults. Rubenstein, Malt

331. Humanistic Psychology (3) SS spring
The literature of and metaphors underlying the humanistic point of view in psychology. These "models of man" are contrasted with models underlying other modes of psychological inquiry. Prerequisite: Psyc 1 or 11. Newman

335. (Biol 335) Animal Behavior (3)
Discussion of the behavior of invertebrates and vertebrates and analysis of the physiological mechanisms responsible for behavioral actions. Emphasis on perception, environmental stimuli, and adaptive value of special behavior patterns. Prerequisite: Biol 21 or consent of the department chairperson. Itzkowitz

337. (Biol 337) Sociobiology (3)
Social systems of vertebrate and invertebrate groups. Emphasis on ecological and evolutionary factors that influence social behavior. Prerequisite: Biol 21 or consent of department chairperson. Not open to students who have taken Biol 498. Itzkowitz

343. (SR 343) Scientific Methods for Applied Social Sciences (3)
Problems in the application of scientific methods in policy relevant research. Prerequisite: introductory statistics or consent of the department chairperson. Campbell

345. (SR 345) Seminar on the Social Evolution of Complex Organizations (3)
Topic varies from year to year. May be taken more than once. Possible topics: Evolution of archaic city states. Role of theism and theocracy. Moral norms as socially evolved curbs to the dysfunctional species-personality produced by biological evolution. Parallel problems in modern bureaucracy. Campbell

347. (SR 347) Seminar on Sociology and Psychology of Science (3)
Specific topic varies from year to year. May be taken more than once. General focus is on those sociological and psychological processes in science that are relevant to the credibility of a science's claim to be improving its validity. Campbell

351. Cognitive Development in Childhood (3) SS
Piaget and alternative theoretical approaches. Research on development of memory, comprehension, communication, classification, and social cognition. Prerequisite: Psyc 107 or consent of instructor.

352. (SpEd 331) Emotional and Behavioral Disorders (3) SS
Definition, classification, etiology, treatment, and historical perspective of individuals with emotional and behavioral disorders.

353. Personality Theory (3) SS fall
Review and critique of theories of personality and their associated systems of psychotherapy. Includes developing knowledge and theory about people as well as the theoretical concepts themselves. Prerequisite: Psyc 1 or 11. Hyland, Williams

354. Personality Assessment (3) SS spring
Methods of describing and measuring personality. Observational techniques, interviews, self-report inventories, intelligence tests, and projective tests. Prerequisite: Psyc 1 or 11, and consent of the department chairperson. Hyland, Williams

361. Special Topics in Adult Development (3) SS
Topic varies from year to year. Personality and social development during the adult years, including sex roles, attitudes toward and stereotypes of the elderly, psychology of death and dying. Prerequisite: Psyc 109 or consent of instructor. Hyland

363. Social and Personality Development (3) SS
Social cognitive, family systems, and psychoanalytic approaches. Research on development of parent and peer relations, sense of self, and social competence from birth to adulthood. Prerequisite: Psyc 107, 108, 109 or consent of instructor. Pipp

371. Theories of Learning (3) NS spring
Critical evaluation of classical and contemporary theories of learning including review of relevant experimental research. Prerequisite: Psyc 171. Brody, Richter

373. Sensation and Perception (3) NS spring
Receptor processes of vision, audition, touch, taste, and smell. Psychological dimensions of such processes leading to consideration of perception as characteristic of organisms. Prerequisite: Psyc 65 or 176 or 177. Shortess

374. Sensation and Perception Laboratory (1) NS spring
Laboratory exercise applying quantitative methods to the study of sensory processes. Prerequisites: Psyc 210; Psyc 373, previously or concurrently. Shortess

375. (Biol 375) Neuroanatomy of Behavior (3) NS
Neuroanatomy and neurophysiology of animal and human behavior. Feeding, thirst, sleep, emotions, learning, and psychopathology. Prerequisite: Psyc 177 or Biol 220 or 223 or 335. Simon, Nyby

376. Physiological Psychology Laboratory (1) NS fall
A survey of techniques in physiological psychology. Prerequisite: Psyc 375, previously or concurrently. Nyby, Shortess

377. Seminar in Physiological Psychology (3) NS
Selected topics examining the physiological and/or genetic determinants of human and animal behavior. Prerequisite: Psyc 177 and consent of instructor. Shortess, Nyby, Simon

382. (Biol 376) Endocrinology of Behavior (3) NS
Hormonal effects upon animal and human behavior. Emphasis on neuroendocrinology of steroid hormone involvement in reproductive behaviors. Prerequisite: Psyc 177 or Biol 220 or 223 or 335. Nyby, Simon

385. (CSc 385) Programming Applications to Psychological Instrumentation (3) NS spring
The computer in the psychological laboratory: PASCAL on the Apple compter: real-time acquisition of data; computer control of experiments. Prerequisites: CSc 11 or CSc 17 and Psyc 114 or consent of instructor. Kay

395. Thesis (3) fall
Written report: Literature review and design of project in selected area of psychology. Intended for senior majors in psychology only. Prerequisite: consent of the chairperson.

396. Thesis (3) spring
Execution of project designed in Psych 395. Final report and oral presentation. Prerequisite: Psyc 395 and consent of the department chairperson.

For Graduate Students

The department of psychology offers the doctor of philosophy degree in general experimental psychology (e.g., learning, physiological, cognitive, developmental, personality, perception). The program emphasizes research and teaching. Students are trained for university teaching or other positions involving basic or applied research.

Requirements for a doctoral degree at Lehigh. The Graduate School requires ninety credit hours for a doctoral degree for those entering with a bachelor of arts or bachelor of science degree; sixty credit hours are required for those entering with the master of arts or master of science. All doctoral candidates are required to spend at least one year in residence, i.e., in full-time work toward the degree.

Requirements for a doctoral degree in the Department of Psychology:

Research
All graduate students are expected to be involved in research throughout their graduate careers. There are also several formal research requirements of the program.

First Year Project. First year students are expected to choose an adviser and begin to work on a research project as early as possible. A written and oral report of the student's research activities must be made to the department at the end of the first year.

Master's thesis. An empirical (data-based) master's thesis is required. An oral presentation of the thesis is made to the department. Students entering with a master's degree may submit their thesis in fulfillment of the departmental thesis requirement with faculty approval.

Doctoral dissertation. This is an original piece of scholarly work. For the doctor of philosophy, this is usually empirical research, although original theoretical or historical research is possible with faculty approval.

Coursework

Proseminar. All students must complete a three-semester proseminar which provides general background in the major areas of psychology. During each semester several faculty members will teach in their areas of specialization.

Psyc 421 and 22, Analysis and Design of Experiments. These courses represent a two-semester sequence of theoretical and applied statistics and research methodology.

Psyc 400+, Graduate Seminars. After completing the proseminar sequence, students must take at least four graduate seminars approved by the faculty. Two of these seminars should be in the student's area of interest and two seminars should be from another area.

Psyc 409, Teaching Seminar. A one-credit discussion group often integrated with current graduate student teaching experiences; required for four semesters.

Teaching
Students are encouraged to participate in teaching as appropriate for their training throughout their graduate years. Normally, students begin as teaching assistants and progress to teaching independently.

Psyc 465, Teaching Internship, involves teaching a course with faculty supervision and follows completion of the master's degree (including an approved thesis).

General Examination
This is required for all doctoral candidates and must be passed at least seven months prior to the awarding of the degree. The student may opt for a major/minor or a major only exam; subareas to be covered on the exam are selected by the student in consultation with the student's general exam committee. An oral examination follows faculty evaluation of the written exam.

Evaluation
Graduate students are evaluated on their performance in course work, research, teaching, assistantship assignments, and the general examination. Following the end of each semester, the faculty provides each student with a written evaluation of progress in the graduate program.

Financial Support
Support is available in the form of teaching and research assistantships, fellowships, and scholarships. There are special fellowships for minority students. While a good undergraduate background in psychology is desirable, promising students with majors other than psychology ar encouraged to apply.

How to apply
Applications for admission and financial aid may be obtained from the Department of Psychology. Completed application forms plus transcripts, letters of recommendation, and a report of scores on the Graduate Record Examination and advanced tests in psychology should be returned to the office of admission not later than February 1 of the year of admission. New students are normally accepted for entrance into the program only for the fall semester.

Graduate-Level Courses

402. (SchP 402, SpEd 402) Behavior Modification (3)
Theory and applications of behavior modification methods in classroom and clinical settings. Methods derived from operant, classical, and cognitive models. Topics include behavior analysis, charting behaviors, outcome research, and ethical and philosophical issues. Prerequisite: HD 400 or its equivalent.

403. Proseminar: Learning and Cognition (3)
Theoretical and empirical issues addressed by faculty members specializing in these areas. Prerequisite: graduate standing in psychology or consent of department chairperson. Brody, Malt, Richter, Williams

404. Proseminar: Biopsychology and Perception (3) spring
Theoretical and empirical issues addressed by faculty members specializing in these areas. Prerequisite: graduate standing in psychology or consent of department chairperson. Nyby, Shortess, Simon

405. Proseminar: Development and Personality (3) spring
Theoretical and empirical issues addressed by faculty members specializing in these areas. Prerequisite: graduate standing in psychology or consent of department chairperson. Hyland, Pipp, Williams

409. Professional Seminar (1) fall-spring
Two hours of class meetings per week of first- and second-year graduate students to discuss teaching psychology and preparing for the profession. May be repeated for credit. Shortess

421. Analysis and Design of Experiments (3) fall
First of a two-semester sequence covering a variety of issues in theoretical and applied statistics with emphasis on inferential statistics and analysis of variance. Richter

422. Analysis and Design of Experiments (3) spring
Continuation of Psyc 421. Prerequisite: Psyc 421. Richter

434. Special Topics in Personality (3)
Selected topics in personality theory and research. Limited to personality change, the self, personality consistency, and the relationships among thought, emotion, and behavior. Prerequisite: Psyc 405 or consent of instructor. Williams

435. Abnormal Psychology (3) fall
The patterns, causes, and treatment of various forms of abnormal behavior. (Intended for graduate students in the College of Education.) Williams

441. Communicating Psychological Concepts (3)
How to organize facts and ideas into broader meaningful units that are readily communicable. Includes media aids. Prerequisite: consent of the department chairperson. Newman

448. (CSc 402) Seminar in Psycholinguistics (3)
Selected topics in psycholinguistics examined in depth and in detail. Prerequisite: CSc 310. Rubenstein

450. Special Topics in Mathematical Models and Statistics (3)
Selected topics in the application of mathematics to psychological research. May be repeated for credit. Brody, Richter

451. (Educ 451) Theories of Learning (3) fall
In-depth study of major classical and contemporary learning theories. Review of experimental research relevant to theories. (Intended for graduate students in the College of Education.) Brody

453. Advanced Topics in Learning (3)
An intensive study with emphasis on current research of discrimination learning, avoidance learning, concept learning, problem solving, or verbal learning. May be repeated for credit. Prerequisite: Psyc 403 or consent of instructor. Brody, Richter

460. Special Study (1-3) fall-spring
Study of some special topic not covered in the regular course offerings. May be repeated for credit.

461. Research Seminar (1-3) fall-spring
Original research projects not connected with master's or doctoral theses are designed and executed in collaboration with the faculty. Students meet with the seminar director to critique each other's projects.

465. Teaching Internship (3-6) fall-spring
The preparation, teaching and grading of one or two undergraduate courses with appropriate supervision by members of the faculty. Observation and evaluation of the intern via classroom visits and videotapes. May be repeated for credit.

471. Applied Psychology Internship (1-6) fall-spring
Supervised, independent field work experience in e.g., industry, a medical setting, or a mental health setting. May be repeated for up to six hours credit.

472. Special Topics in Physiological Psychology (3)
Examination of the biological substrates of behavior. Topics may include animal communication, sociobiology, behavioral endocrinology, or behavior genetics. May be repeated for credit. Prerequisite: Psyc 404 or consent of instructor. Nyby, Simon

473. (Coun 457) Personality and Adjustment (3)
Theories of personality and adjustment with emphasis on the adjustment processes in an educational setting. Prerequisite: consent of the program director. Hyland, Williams

474. (Educ 474) Psychological Development in Childhood (3) spring
Survey of theories and research concerning perceptual, cognitive, social, and personality development through infancy and childhood. (Intended for graduate students in the College of Education.) Hyland, Pipp

475. (Coun 460) Theories of Psychological Counseling (3)
Analysis and synthesis of concepts drawn from counseling theorists. Research and current trends in counseling concerning educational, social and vocational problems. Prerequisite: admission to program in counseling.

476. Seminar in Cognition (3)
Selected topics in human information processing, including such areas as attention, memory, language and comprehension, and decision-making. Area of emphasis will vary from year to year. Prerequisite: Psyc 403 or consent of instructor. Malt

480. Seminar in Cognitive Development (3)
Selected topics in cognitive development in infancy and childhood, including such areas as conceptual development, memory development, the development of reasoning abilities, and language acquisition. Emphasis will vary from year to year. Prerequisite: Psyc 405 or consent of instructor.

481. Seminar in Social Development and Personality (3)
Social cognition, family systems, and psychoanalytic approaches to social and personality development from birth through adulthood. Prerequisite: Psyc 405 or consent of instructor. Pipp

482. Seminar in Adult Development (3)
Application of lifespan developmental theory and methodology to personality, social, and cognitive development in adulthood. Prerequisite: Psyc 405 or consent of instructor. Hyland

486. Seminar in Clinical Psychopharmacology (3)
Examination of diagnostic issues and pharmacological intervention strategies in the treatment of neuroses, psychoses, and other psychological/psychiatric problems. Emphasis on consideration of current primary references with evaluation through student presentations. Prerequisite: Psyc 404 or consent of instructor. Simon

487. Seminar in Visual Perception (3)
Examination of selected topics of current interest in visual perception from behavioral, cognitive, and neurophysiological approaches. Prerequisite: Psyc 404 or consent of instructor. Shortess

Religion Studies

Professor. Hubert L. Flesher, M.A. (Yale).
Associate professors. Alice L. Eckardt, M.A. (Lehigh); Norman J. Girardot, Ph.D. (Chicago), *chairman;* Laurence J. Silberstein, Ph.D. (Brandeis), *Philip and Muriel Berman Chair of Jewish Studies, and director, Lehigh Valley Center for Jewish Studies.*
Assistant professors. James J. Reid, Ph.D. (U.C.L.A.); Lydia A. Speller, D.Phil. (Oxford).
Instructor. Michael Raposa, M.A. (Yale).

Religion studies is committed to the academic investigation of religion as an intrinsic and vital dimension of human culture. The scholarly study of religion is an integral facet of liberal education. The student of religion is engaged in the critical and interpretive task of understanding patterns of religious thought and behavior as aspects of the human cultural experience.

Religion studies is interdisciplinary in that it draws upon humanistic (involving historical and philosophical perspectives), social scientific (involving sociological, anthropological, and psychological perspectives) modes of inquiry. Religion studies is a cross-cultural, comparative discipline concerned with the character and significance of the major religious traditions of the world. The student of religion confronts ethical problems and foundational issues of value and meaning raised by modern pluralistic and technological society.

Program of Study

Courses in the department of religion studies reflect the interdisciplinary and cross-cultural nature of the field. The various offerings in the department focus on three interrelated areas.

Historical courses stress the nature and development of particular religious traditions from both the East and the West—e.g. Judaism and Hebrew Scriptures; New Testament; Christianity I and II; The Islamic Tradition; Religions of Japan; Religions of China; Religion and the American Experience; and Religions of India.

Comparative and thematic courses concentrate on special historical or methodological topics related to the general cultural significance of religion—e.g. The Jewish-Christian Encounter, Sex and Gender in Religious Traditions, Islam in the Modern World, Topics in Asian Religions.

Analytical courses are concerned with the significance and meaning of religion in the contemporary secular and technological world (involving philosophical, ethical, theological, sociopolitical, and aesthetic questions)—e.g. Science, Technology and the Religious Imagination; Religion and the Arts; Contemporary Theology; Myth and Meaning in Religion; Religion, Ethics, and Society; Topics in the Philosophy of Religion.

Opportunities in the Study of Religion

Students are encouraged to enroll in any course offered by the department, either as general electives or in a major/minor program. The interdisciplinary character of religion studies

makes the pursuit of a major/minor concentration in relation with other fields especially appropriate. Religion studies may be combined with other fields as part of a joint major, double major, or minor program.

A major or minor program linked to other humanistic or social scientific fields is therefore both recommended and invited. Lehigh students have, for example, combined a religion studies major not only with traditional humanistic disciplines but also with such diverse fields as mechanical engineering, electrical engineering, economics, biology, mathematical physics, social relations, international relations, and psychology. Special programs of study can be tailored to the specific needs and interests of the student.

Since religion studies addresses fundamental questions of personal value and social concern, students have found a concentration in the study of religion a stimulating complement to pre-professional programs in law, medicine, business, foreign careers, and journalism. The study of religion is especially applicable to vocations in teaching, ministry, counseling, social work, journalism, and publishing.

Some background and training in religion studies is most of all an excellent preparation for careers where a broad liberal education, cross-cultural awareness, critical modes of thought, and a concern for human values are important.

Major in Religion Studies

Students are particularly encouraged to consider a joint or double major with another major field from any of the three colleges at the university. RS 10 and 11 are the foundational courses required of all majors (exempted only with permission of major advisor and chairperson). One course from each of the following three areas is required (with permission of the advisor, some courses may qualify for more than one area).

Area 1 (historical courses stressing the nature and development of particular religious and scriptural traditions from both East and West): R.S. 73, 103, 105, 107, 108, 111, 114, 115, 116, 117, 119, 157, 355.

Area 2 (comparative and thematic courses concentrating on special topics related to the general cultural significance of religion): R.S. 53, 61, 71, 109, 121, 127, 137, 141, 151, 153, 154, 165, 171, 221, 241, 251.

Area 3 (analytical courses concerned with religion in relation to the contemporary world—involving ethical, philosophical, theological, social-political, and aesthetic questions): R.S. 106, 124, 133, 134, 135, 145, 163, 165, 167, 221, 224, 237, 335.

In addition to this minimum distribution, we advise a concentration in one of the three areas, *or* in one of the major religious traditions. The concentration should include at least four courses, where that is possible. Language study appropriate to the concentration is also recommended. Total of 10 courses (30 credits) for the major.

During his or her first two years, the prospective major should take RS 10 and 11, one course in their projected area of concentration and one outside of that area.

Religion studies majors are encouraged to supplement their studies through related course offerings in such interdisciplinary programs as the Jewish Studies program (see page 30), the East Asian Studies program (see page 29). and the Science, Technology, and Society program (see page 31).

Those who plan to pursue graduate work are advised to study a foreign language or languages related to their area of concentration (i.e. Hebrew, Greek, and Latin for Western traditions and Chinese or Japanese for Eastern traditions). With sufficient student demand, the department can make arrangements for credit instruction in Biblical Hebrew, New Testament Greek, Classical Persian, Japanese and Classical Chinese.

Departmental Honors
Religion Studies majors are admitted to honors by invitation of the departmental faculty toward the end of the student's junior year. To be eligible, a student must have attained at least a 3.25 average in his or her major program by the end of the junior year. Upon admittance to honors, the student will work out a special program of studies for the senior year with the major adviser (typically involving special directed reading courses, a senior essay, etc.).

Minor in religion studies. The minor in religion studies consists of a total of fifteen credits. The specific courses to be taken by each student are to be decided upon jointly by the student and the departmental advisor. Ordinarily, the student will be expected to take RS 10 or 11 unless specifically exempted by the departmental chairman.

Recommended preliminary distribution courses. Any religion studies course may be taken to meet the Humanities distribution requirement. Freshmen may enroll in any 100-level religion studies course with the consent of the instructor. Religion studies courses such as RS 101, 107, 109, 111, 114, 115, 117, 119, 121 qualify for the Foreign Culture distribution requirement (consult updated distribution requirement lists for other religion studies courses fulfilling the Foreign Culture option).

Recommended upperclass distribution courses. Any course at the 100 level or above may be taken.

Courses of Study

Freshmen must petition to take courses numbered 100 and higher; sophomores must petition to take courses numbered 200 and higher.

10. Introduction to the Study of Religion (3)
Basic issues and methods in religious studies. "What is religion?": the problem of definition. Role of religion in individual and group life. Staff

11. Religions of the World (3) fall, spring
The world's major religious traditions: Judaism, Christianity, Islam, Hinduism, Buddhism, Chinese and Japanese religions. Staff

53. (Hist 53) Religion and the American Experience (3)
The historic development of major American religious groups from colonial times to the present. Their place in social and political life, and the impact of the national experience upon them. Emphasis on religious freedom and pluralism, and the church-state relationship. Eckardt

61. End of the World (3)
Expectations of future destruction and bliss in biblical and other writings. Social function of millennial religious groups. Speller

71. Limits of Christian Tolerance (3)
Consideration of conflict between Christianity's teaching of love, mercy, and justice, and its institutional history of exclusivism and persecution. Topics include changing Christian attitudes toward heresy, religious enthusiasm, witchcraft, sexual non-conformity, non-Christian religions and secular science. Speller

73. Introduction to Judaism
Development of traditional Judaism; readings in the Bible, the Talmud, and selected mystical texts. Discussions will focus on the diverse ways in which Judaism has been understood and interpreted up until the end of the 18th century. Silberstein

103. (Hist 103) Christianity I: Early and Medieval (3) fall
Historical and theological investigations of Orthodox and Catholic traditions. Issues of doctrine, authority, community and liturgy. Speller

105. Christianity II: Reformation and Modernity (3) spring
Origin and development of the major forms of Protestant

Christianity. Interactions with Catholic traditions. Issues of faith, reason and religion, scriptural authority. Speller

106. Contemporary Roman Catholicism (3)
A survey of the various intellectual, cultural, political and ecclesiastical developments that have shaped contemporary Roman Catholic life and thought. Raposa

107. The Islamic Tradition (3)
Origin and development of classical Islam. Topics include Muhammad and the Koran; legal, theological, and ritual institutions; the Caliphate; Islamic mysticism; Islamic cosmology and Islamic science. Reid

108. Modern Judaism and the Search for Meaning (3)
Fundamental themes in the experience of modern Jewry; confrontation with secular culture; crisis of religious faith, Zionism and the renewal of Jewish nationalism, the problem of Jewish identity in America; and the impact of the Holocaust.

109. Islam in the Modern World (3)
Islamic world during the nineteenth and twentieth centuries. Islamic responses to colonialism and modernization. Islamic movements in North Africa, Arabian Peninsula, Central Asia, Iran, India, and the Arab world. Reid

111. The Hebrew Bible/Old Testament (3) fall
Theological examination of a major portion of the Hebrew scriptures, with emphasis upon literary, historical and critical problems. The near Eastern context of Hebraic religious development; the Exodus tradition and the Patriarchal Period; the conquest of the land; the development and dissolution of the monarchy; the prophetic movement. Flesher

114. New Testament (3) spring
Study of early Christianity, with emphasis upon early Apostolic writings. The Synoptic Gospel; the Fourth Gospel; Paul's writing; the later Epistles; the Apostolic Fathers; the development of Gnosticism; parallel Hellenistic religions; newly discovered secret gospels from the second century. Speller, Flesher

115. Religions of China (3)
History and meaning of the major forms of Chinese religion-especially Confucianism and Neo-Confucianism, Taoist mysticism, Buddhism (Ch'an/Zen), and popular religion. Girardot

116. Zionism and the Renewal of Judaism (3)
New interpretations of Judaism, the Jewish community and Jewish history developed by Zionist thinkers. Diverse currents within Jewish Nationalist thought and critical responses to Zionist ideology. Silberstein

117. Religions of Japan (3)
Origins and development of the major forms of Japanese religion (Shinto, Confucianism/Taoism, Buddhism, folk religion) in their cultural context; interaction with Chinese tradition; consideration of role of religion in shaping contemporary Japanese character. Girardot

119. Religions of India (3)
Origin, development and meaning of the major forms of Indian religious traditions. Attention to elite and popular forms of Hinduism, Yoga, early Buddhism. Staff

121. Gospels (3)
Study of Matthew, Mark, Luke, John, and "other gospels" (some only recently rediscovered) from early Christianity not included in the New Testament canon. Relation of gospels to Jewish and Greco-Roman stories of healers, miracle workers, saviors, and teachers. Speller

124. (Phil 124) Reason and Religious Experience (3)
A critical look, from a philosophical perspective, at some fundamental problems of religion: The nature of religious experience and belief, reason and revelation, the existence and nature of God, the problem of evil, and religious truth. Hare, Raposa

127. Sex and Gender in Judaism: The Feminist Critique
Writings by Jewish feminists reflecting the encounter between Judaism and feminism: prayer and ritual, women rabbis, God and God language, communal power, and marriage and divorce. Silberstein

133. Science, Technology, and the Religious Imagination (3)
Impact of the scientific and technological culture on the Western religious imagination. Roots of science and technology in religious ideas and images. Ways of knowing and concepts of experience in religion and science. Raposa

134. Religion, Ethics and Society (3)
Selected readings in philosophical and theological ethics combined with the discussion of specific moral issues. The relationship between religious and secular values. Raposa

135. Myth and Meaning in Religion (3)
Inquiry into the meaning of religious symbols, myths and rituals. Historical perspectives; philosophical and methodological problems. Readings in the works of Otto, Cassirer, Eliade, and Levi-Strauss. Girardot, Raposa

137. (Anth 137) Prehistoric Religion and Technology (3)
Origins and early development of religions, with focus on interactions of religion, magic, and technology, especially as these correlate with hunting, agriculture, and pastoral modes of subsistence. Girardot

141. Literature of the Holocaust (3)
Readings from the literature that records, interprets and evaluates the Nazi Holocaust of the Jews in order to consider the psychological, moral, intellectual and religious implications. Consideration of the relevancy of these implications for other genocides and massacres. Eckardt

145. Jewish Thought Since the Holocaust (3)
Reactions to the Holocaust by major Jewish thinkers such as Wiesel, Rubenstein, Fackenheim, Buber, Heschel, Schulweis, and Berkovitz. Focus on the problem of evil and its relationship to religious faith. Silberstein

147. Near Eastern Traditions and the Rise of Monotheism (3)
Semitic, Indo-Iranian, Turkic religions. Polytheism's contributions to monotheisms. Hebrew religion, Christianity, Islam, Zoroastrianism, Buddhism and Hinduism. Religious texts, cultural institutions, and social developments. Reid

151. The Jewish-Christian Encounter (3)
Historical analysis of relations between Jewish and Christian communities. Attention to doctrinal and liturgical similarities and differences. Special emphasis on the twentieth century. Eckardt

153. Sex & Gender in Religious Traditions (3)
Attitudes towards men and women, sin and sexuality, and language about God in religious traditions. Celibacy, marriage, divorce, homosexuality. Speller

154. (Hist 154) The Holocaust: History and Meaning (3)
The Nazi holocaust in its historical, political and religious setting. Emphasis upon moral, cultural and theological issues raised by the Holocaust. Eckardt

157. (Hist 157) The Renaissance and Reformation (3)
The transition from medieval to modern society. Consideration of political, economic, and social forces produced by the Renaissance and their influence upon the dominant religious theme of the Reformation era. Baylor

163. Contemporary Theology (3)
Major twentieth century movements within Christian and Jewish theology understood as responses to the problems of

modern times. May be repeated for credit as the subject matter varies. Staff

171. Religion and the Arts (3)
Examination of religious themes in such areas as literature, film and painting, with shifting content from term to term. Alternate fields of study include world literature, modern prose works, the contemporary American novel, Holocaust literatures, and science fiction and fantasy. May be repeated for credit as the subject matter varies. Staff

213. (Clss 213) Ancient Roman Religion (3)
Religious experience of the Roman people from prehistory to end of the Empire. Nature of polytheism and its interactions with monotheism (Christianity, Judaism). Theories of religion. Emphasis on primary source materials.

221. Topics in Asian Religions (3)
Selected thematic and comparative issues in different Asian religious traditions. Topics may include Buddhism and Christianity, Religion and martial arts, Asian religions in America, Taoist meditation, Zen and Japanese business, Buddhist ethics. May be repeated for credit as the subject matter varies. Girardot

224. (Phil 224) Topics in the Philosophy of Religion (3)
Selected problems and issues in the philosophy of religion, may be repeated for credit as the subject matter varies. Raposa, Hare

235. Islamic Mysticism (3)
Origins and development of mysticism, cosmology and universality, philosophy and mystical teachings, allegory and metaphor in mystical literature and art; mysticism and existential meaning in modern Islam. Reid

237. (Phil 237) Kierkegaard and Nietzsche (3)
Two maverick thinkers of the 19th century, concerned with religious faith, values, and the meaning of human existence. Melchert

244. Major Figures in Modern Jewish Thought (3)
Focus on one or two major thinkers such as Buber, Rosenzweig, Scholem, Kaplan, and Heschel. May be repeated for credit as the subject matter varies. Silberstein

251. (Clss 251) Classical Mythology (3)
Myth, religion and ritual in ancient Greece and Rome. Emphasis on primary sources; introduction to ancient and modern theories of myth. Cross-cultural material.

257. Jewish Thought Since the Enlightenment (1750 to Present) (3)
Crisis of tradition, conflicting definitions of Judaism, and the limits of interpretation as reflected in the Jewish Enlightenment (Haskalah); religious reform; Neo-Orthodoxy; Zionism and Jewish feminism. Silberstein

265. Great Figures in Western Religion (3)
In depth study of the life, times, and writings of important shapers of Western religious traditions. Emphasis on careful reading of representative works of such figures as Augustine, Maimonides, Averroes, Martin Luther, Martin Buber. May be repeated for credit as the subject matter varies. Staff

335. (Anth 335) Religion, Symbolism and Cosmology (3)
How human experience is mediated through the use of symbols. Religious and cosmological systems in cross-cultural perspective. Frankel, Gatewood

355. (Hist 355) European Intellectual History (3)
Political and religious thought and other aspects of the history of ideas in Europe from the Middle Ages to about 1700. Baylor

361. Fieldwork (3)
Opportunity for students to work, or observe under supervision, religious organizations or institutions. Consent of chair required.

371. Special Topics (1-3)
Intensive study in areas appropriate to the interests and needs of students and staff.

Russian and Russian Area Studies

See listings under Modern Foreign Languages and Foreign Careers.

School Psychology

See listings under Education.

Science, Technology and Society

Steven Louis Goldman, Ph.D. (Boston), Andrew W. Mellon Professor in the Humanities, *program director.*

The Science, Technology and Society (STS) Program is the product of a continuing intercollege effort to create a common ground from which to explore the relations between science, technology and society: between ideas, machines and values.

The STS Program serves as a focal point for a wide range of courses that study the natures of science and of technology, and analyze their social and personal implications. It lends coherence and visibility to offerings otherwise dispersed throughout the catalog.

The Program also offers a minor in *Science, Technology & Society* Studies which is open to all undergraduates. Students electing the minor must take a set of six courses (engineering majors need only take five) clustered about one of four areas of concentration:
(1) science, technology and society;
(2) science, technology and human values;
(3) engineering and society;
(4) science, technology and Western culture.

Minors must take STS 11: *Technology and Human Values,* any four courses (for engineering majors, any three courses) in one of the above areas, and one course in any other area. A list of all courses eligible for the STS Studies minor follows, divided according to concentration.

Science, Technology and Society Courses

11. Technology and Human Values (3) fall
Impact of technology on society in relation to ethical problems raised by the exploitation of technological innovations. Illustrations from literature, art, philosophy, history, folklore, and film. Goldman

113. Science and Human Values (3) spring
Investigation of the relationship between theories of nature and theories of Man. Classical, modern, and contemporary scientific interpretations of nature examined for the interpretations of Man embedded in them. Goldman

121. Nuclear Power and Public Policy (3)
The course will examine nuclear power technology in the broad context of engineering, industrial, and political decision-making relevant to satisfying American society's

energy demands. The status of alternative power technologies will be reviewed and the policies of European nuclear programs will be described. Goldman

124. (Jour 124) Politics of Science (3) spring
Organization of the U.S. scientific community and how it interacts with government, the mass media and the public. Friedman

145. (Hist 145) Introduction to the History of Science (3)
The history of modern science, primarily physical and biological, with emphasis on the development of major theoretical models since the seventeenth century.

181. Independent Study fall-spring
Prerequisite: consent of the program director.

Other STS courses. The following courses, appropriate to the STS Studies minor, are offered by various departments. Course descriptions may be found under the catalog entry for the individual department. New courses are frequently added to this list and announced in bulletins published by the STS Program. For further information, please contact the program director.

I. Science, Technology and Society

Anth 131	Science, Technology and Society—Frankel
Anth 151	Utopias and Alternative Communities—Frankel
CSc 252	Computers and Society—Barnes
Eco 311	Environmental Economics—McNamara
Eco 314	Energy Economics—McNamara
Govt 111	The Politics of Environment and Natural Resources (3)—Wurth
IR 41	Science, Technology & International Relations—Slouka
IR 80	Politics of Oil—Staff
IR 85	Alternative World Futures—Wylie
Soc 135	Medicine and Society—Lasker
Jour 123	Basic Science & Technical Writing—Friedman
Jour 125	Environment, Public, and Mass Media—Friedman
Jour 128	Writing for Public Relations—Friedman
Jour 311	Science and Technical Writing—Friedman
Jour 312	Advanced Science and Technical Writing—Friedman
Jour 313	Special Topics in Science and Technical Writing—Friedman
STS/Jour 124	Politics of Science—Friedman

II. Science, Technology and Human Values

Engl 89	Science Fiction—Arbur
Engl 119	Literature and Technology—Gallagher
Engl 150	Media and Values—DeBellis
Engl 187	Themes in Literature: Utopia: Fantasy or Reality—Harson
STS 11	Technology and Human Values—Goldman
STS 113	Science and Human Values—Goldman
Mus 153	Electronic Music—Salerni
Psyc 65	Art and Visual Perception—Shortess
Phil 114	War, Morality, Ethics, and Military Professionalism (3)—Hare
Phil 115	Business Ethics—Staff
Phil 116	Medical Ethics—Staff
Phil 128	Philosophy of Science—Bearn
Phil 250	Minds of Men and Robots—Melchert
RS 133	Science, Technology & The Religious Imagination—Raposa
RS 134	The Professions, Ethics and The Religious Life—Raposa
RS 137/Anth 137	Prehistoric Religion and Technology—Girardot

Engineering and Society

STS 121	Nuclear Power and Public Policy—Goldman
STS/Met 221	Materials and the Development of Man—Notis
Thtr 161	Theater Design and Engineering—Milet
Geol 11	Environmental Geology—Evenson

Engineering and Society—Bolle and Goldman
Chemistry for the Consumer—Heindel
Computer Modeling of Our World—Schiesser
Urban Design and the Skyscraper—Beedle
Regulation of Industry and Public Safety—Pense
Factory of the Future—Groover
Mineral Deposits, Industrial Development and World Affairs—Sclar

Science, Technology and Western Culture

Arch 207	Renaissance Architecture—Adams
Arch 209	Architecture, 1750-1880—Adams
Arch 210	20th-Century Architecture—Adams
Clss 108	Ancient Technology—Staff
Clss 204	Ancient City and Society—Staff
Hist 7	Machine in America—Simon
Hist 8	History of Medicine in America—Ellis
Hist 207	Seminar in the History of Technology—Simon
Hist 337	History of Medical Thought—Ellis
Hist 339	Human Ecology and Public Health in America—Ellis
Hist 340	Topics in American Medicine—Ellis
STS/Hist 145	Introduction to the History of Science—Goldman

Interdisciplinary Technology Courses

Several courses have been developed to make students better aware of the role that science and technology play in society. They are intended primarily for non-science and non-technology students, but science and engineering majors may also take them. None of these courses may be used to satisfy distribution or general studies requirements. These courses are taught by faculty from the College of Arts and Science and the College of Engineering and Applied Science. Course numbers may vary by semester; consult STS Program or College Deans' offices for specific details.

The current listing of courses includes:

Chemistry for the Consumer (3)
Chemical areas of consumer concern as a vehicle for teaching chemical principles of atomic structure, bonding, stoichiometry, reactivity, structure-property relationships, and inorganic and organic compound types. Issues of consumer protection from harmful chemical products vs. the hidden costs of governmental regulations as policy problems for the educated (but non-chemical) consumer. An attempt to provide the liberal arts student with a close up view of how chemists face practical problems. Reactions, pathways, and the language of chemistry will be presented for mastery. (May not be used to satisfy distribution or general studies electives.) Heindel

Computer Modeling of Our World (3)
How classic strategies of the humanities and social sciences to the solution of large-scale social problems are being supplemented by sophisticated quantitative computer-based models. To achieve a minimum 'literacy' in this new use of computers, students in this seminar will have firsthand experience with computer models of world socioeconomic (and perhaps other) systems. Emphasis will be given to the assumptions made in constructing models, and upon the limitations of such models. Study will require only high school mathematics. (May not be used to satisfy distribution or general studies electives.) Schiesser

Urban Design and the Skyscraper (3)
Development of modern cities, the emergence of urban planning and design, and the social effects of the high-technology urban environment. Focus upon the role of the tall building and the social and technical factors—in science or mathematics—entering into the design and construction of such facilities. Topical material includes: building systems (structural, mechanical, architectural), the tall-building design team, the design of structural members, taking potential natural and man-made hazards into account. (May not be used to satisfy distribution or general studies electives.) Beedle

Regulation of Industry and Public Safety (3)
The growth of the regulation of public safety from the industrial revolution to the present. The basic principles of engineering—taught in a primarily qualitative manner assuming no background in science or mathematics—involved in developing safety codes. Examples will be drawn from the bridge construction, pressure vessel manufacturing, and nuclear industries, examining the strengths and weaknesses of the present system of regulation. Examples will be given of typical failures in the regulation process, and the future of regulation will be discussed. (May not be used to satisfy distribution or general studies electives.) Pense

Factory of the Future (3)
Current and future automated production systems that promise to transform American society by reducing the labor intensivity of manufacturing. Using primarily qualitative teaching approaches—no background in science, engineering, or mathematics is assumed—such topics as the growing use of industrial robots, computer-aided manufacturing techniques, and computer-aided design will be explored. Consideration will be given to the social impact of future automated factories. (May not be used to satisfy distribution or general studies electives.) Groover

Engineering and Society (3)
An introduction to engineering as a distinctive problem-solving discipline and as a social force. Emphasis will be placed upon the roles played by society in defining engineering problems and in limiting the terms of their solution, as well as to design, decision analysis, and modeling as central to engineering as a mode of reasoning. This course is open to students from all three colleges—but is intended primarily for liberal arts and business majors. (May not be used to satisfy distribution or general studies electives.) Bolle, Goldman

Mineral Deposits, Industrial Development and World Affairs (3)
An integrated view of the science and technology underlying the discovery, development, and utilization of useful mineral deposits within the historical and economic framework of the industrial revolution. Topics to be treated—in a primarily qualitative manner assuming no background in science or mathematics—include: geological principles and processes which control the localization of mineral deposits in the earth's crust, impact of raw material supplies of the evolving third-world states, and potential raw-material crisis for the industrialized nations. (May not be used to satisfy distribution or general studies electives.) Sclar

Social Psychology

See listings under Social Relations.

Social Relations

Professors. Donald T. Campbell, Ph.D. (Berkeley), *University Professor of Social Relations and Psychology;* Barbara B. Frankel, Ph.D. (Princeton); Roy C. Herrenkohl, Ph.D. (N.Y.U.); James R. McIntosh, Ph.D. (Syracuse), *chairperson;* Robert E. Rosenwein, Ph.D. (Michigan).
Associate professors. Thomas O. Blank, Ph.D. (Columbia); John B. Gatewood, Ph.D., (Illinois); Judith N. Lasker, Ph.D. (Harvard).
Assistant professor. Kandi M. Stinson, Ph.D. (North Carolina at Chapel Hill).

Social relations, broadly conceived, is the study of human beings in relationships with others. As such, it encompasses the study of the broadest range of human social activities from the comparative examination of widely divergent cultures and societies to the inner life of the individual as this influences social behavior.

The three disciplines represented in this department—anthropology, sociology and social psychology—have as their goal to foster both self-awareness and societal awareness by providing students with the knowledge and analytic skills necessary to the accomplishment of these aims. The disciplines represented in the program provide a student with a clearer understanding of self. To study social relations is to develop a sense of the influences that have shaped one's past and pattern one's future.

But self-awareness is only a beginning. Human behavior occurs within diverse settings, groups and other collectivities. Coping with and resolving conflict, reducing strain and tension, and managing and building cooperation are central themes of study in departmental courses. Whether in the study of primitive kinship systems, the messages of nonverbal behavior, or the elements of wealth and power, one comes closer to an understanding of social life in organizations, organizational behavior and the structure of groups and societies.

Research Opportunities

It is the explicit aim of the social relations department to involve majors, minors and other interested students in the ongoing research activities of faculty members. A list of current research programs and research assistant opportunities is maintained in the departmental office in Price Hall.

Second-semester sophomore, junior and senior students interested in a supervised research experience are invited and encouraged to consult the list and talk with the appropriate faculty member. Course credit may be received for research experience.

Fieldwork in Social Relations

The department maintains close, working relationships with a variety of social agencies and institutions in the area. Students may earn course credit by carrying out supervised work in field settings, e.g., hospitals, private and public agencies devoted to social services, courtrooms, prisons, etc. This useful experience allows a student to apply the concepts learned in the classroom to a field setting and to evaluate vocational aspirations and interests.

Students interested in social work may take courses in the Social Work Education Program, an undertaking of the Lehigh Valley Association of Independent Colleges. For further information, contact the social relations department.

Social Relations and Careers

Social relations majors are found in business, industry, government, the service areas, and the academic world. Some Lehigh students have gone on to earn the master's degree or the doctor of philosophy. Many have sought professional degrees. For example, training in the social sciences is excellent preparation for law school or seminary programs. Most students go from the university directly to work. Graduates are planners, administrators, case-workers, interviewers, personnel officers, health and welfare workers, sales representatives, consultants, researchers, media managers, owners of their own business, as well as career military people.

A major in social relations provides a strong core around which students can develop career-based programs of study.

For example, a person interested in public health would add courses in biology, management and psychology to the requirements for the social relations major. Someone interested in personnel work might take courses in psychology, management, and marketing. A prospective law student might elect the Law and Legal Institutions minor in addition to the social relations major. A student who is interested in a career in the social services or the helping professions might elect a double major in social relations and psychology or an interdisciplinary major in those two fields.

Of particular interest to those students in a career in business administration is the bachelor of arts-master of business administration degree (Arts B.A.-M.B.A.). In this option, a student would major in social relations, take requisite courses in the College of Business and Economics, and then take additional study in business administration beyond the bachelor of arts degree. This program is described in more detail in the College of Arts and Science entry, Section III.

A list of updated university courses specific to these options is on file in the departmental office. There are, of course, many other career possibilities. Students interested in formulating a particular career-based program of study should consult the department chairperson, who serves as department career adviser.

Major Requirements in Social Relations

A major in social relations consists of 36 hours of course work. This total includes 15 credits of core courses (6 in introductory level courses and 9 in theory and methodology) and 21 hours of electives. Students are required to have a minimum of 6 hours from each discipline. A student may concentrate in any one discipline by taking 12 elective credits in anthropology, social psychology, or sociology.

Core Courses (15)

Introductory (6)

Anth 11	Sociocultural Anthropology (3) **or**
Anth 12	Emergence of Mankind and Culture (3)
SPsy 21	Social Psychology (3)
Soc 5	Introductory Sociology (3)

Theory and Methodology (9)

SR 111	Research Methods of Social Relations (3)
SR 377	Computer Applications in Social Relations (4)
SR 381	Development of Social Theory (3)

Elective (21 hours)

Requirements for the Minor

Social relations: One introductory course, SR 111 and nine additional credits at the 100 level or above, three hours from each discipline.
Anthropology: Anth 11 or 12, SR 111 and nine additional credits at the 100 level or above in anthropology.
Social Psychology: Soc Psych 21, SR 111 and nine additional credits at the 100 level or above in social psychology.
Sociology: Soc 5, SR 111 and nine additional credits at the 100 level or above in sociology.
Interpersonal Behavior in Small Groups and Organizations: See description under Special Academic Opportunities.

Honors Option

A student may be graduated with honors by completing an independent project supervised by one or more members of the faculty. Students who elect this option will be required to take a readings course (SR 371 or 372) and SR 399 (senior project).

Students who intend to go on to graduate school should particularly consider electing the honors option. The department chairperson should be consulted for further details.

Undergraduate Courses in Social Relations

SR 41. Human Sexuality (3)
Sexuality and gender roles across the life cycle, including human reproduction, decision-making, and the societal regulation of sexual behavior. Stinson

SR 111. Research Methods of Social Relations (3) fall
Theory and methodology of research in social relations. Use of contemporary journals and other materials as an introduction to research skills in anthropology, sociology and social psychology.

SR 112. Research Methods in Social Relations (3) spring
Continuation of SR 111. Developing skills in conducting social research. Prerequisite: SR 111.

SR 118. Close Personal Relationships (3)
Dynamics of development, maintenance and dissolution of relationships with family, close friends, lovers and spouses. Life cycle of relationships, attraction, communication.

SR 171. Seminar in Social Relations (3)
Topics in social relation, anthropology, sociology, and social psychology. Topics vary. May be repeated for credit.

SR 331. Social Perspectives on Death and Dying (3)
The meaning of the end of life in various societies, especially the United States. Sociological, anthropological, and psychological perspectives on dying as a process, and on death as an event, combined with philosophical and ethical considerations. Topics to be considered include euthanasia and "extraordinary means" to maintain life from neonate to elderly, funeral practices, stages of dying, hospices, and the social milieu and family relationships of the dying person. Blank

SR 343. Scientific Method for Applied Social Sciences (3)
Problems in the application of scientific methods in policy relevant research. Prerequisite: introductory statistics or consent of the department chairperson. Campbell

SR 345. (Psyc 345) Seminar on the Social Evolution of Complex Organizations (3)
Topic varies from year to year. May be taken more than once. Possible topics: Evolution of archaic city states. Role of theism and theocracy. Moral norms as socially evolved curbs to the dysfunctional species-personality produced by biological evolution. Parallel problems in modern bureaucracy. Campbell

SR 347. (Psyc 347) Seminar on Sociology and Psychology of Science (3)
Specific topic varies from year to year. May be taken more than once. General focus is on those sociological and psychological processes in science that are relevant to the credibility of a science's claim to be proving its validity. Campbell

SR 363. Seminar in Social Relations (1-4)
Selected social science topics.

SR 365. Fieldwork in Social Relations (1-3)
Supervised work experience and observation in a variety of field settings, e.g., hospitals, social services, public agencies, private organizations. Prerequisite: consent of chairperson. Lasker, Rosenwein

SR 371. Special Topics in Social Relations (1-3)
An opportunity for advanced work through supervised reading and research. Prerequisite: consent of the department chairperson.

SR 372. Special Topics in Social Relations (1-3)
Continuation of SR 371.

SR 377. Computer Applications in Social Relations (4)
Uses of micro- and mainframe computers in the social sciences, including data management, statistical analysis, and simulations. Weekly laboratory sessions.

SR 381. Development of Social Theory (3)
Comparative study of social theory.

SR 393,394. Independent Research (3-4)
Students will conduct research under faculty supervision. Prerequisite: consent of the department chairperson.

SR 395. Methods in Observation (3) alternate years
Naturalistic and participant observation in uncontrolled field settings. Frankel or Rosenwein

SR 399. Senior Project (3)
Independent work fulfilling honor requirements. Prerequisite: SR111 or 112, or consent of the department chairperson.

Anthropology

Anth 11. Sociocultural Anthropology (3)
Human behavior in cross-cultural perspective. Variations in kinship reckoning, political organization, economic and religious life in comparative perspective. Particular non-Western peoples: films and readings.

Anth 12. Emergence of Mankind and Culture (3) NS
Introductory biological anthropology and prehistory. Adaptive function of human culture and its relation to biological evolution. Hominid fossil record, nonhuman primate social behavior, cultural beginnings, and survey of world prehistory. Gatewood

Anth 128. Urban Ethnology (3)
Cross-cultural study of the city as a social milieu. Comparison of methods and strategies for research in urban settings, and the explicit and implicit theories of urban life associated with these. Field projects will use Bethlehem's South Side as an ethnographic laboratory. Frankel

Anth 131. Science, Technology and Society (3)
Relationships of science and technology to social life across time and space, with alternative theoretical models for understanding these relationships. Frankel

Anth 137. (Rel 137) Prehistoric Religion and Technology (3)
Origins and early development of religions, with focus on interactions of religion, magic, and technology, especially as these correlate with hunting, agriculture, and pastoral modes of subsistence. Girardot

Anth 151. Utopias and Alternative Communities (3)
Present and past searches for new forms of community in fact and fiction. Frankel

Anth 182. North American Indians (3)
Culture areas of native North America prior to substantial disruption by European influences north of Mexico. Environmental factors and cultural forms. Gatewood

Anth 184. Cultures of the Pacific (3)
Cultures of the Pacific Islands: language families, prehistories, and social organizations. Focus: Melanesian cultures. Gatewood

Anth 321. Anthropology of Physical and Mental Health (3)
Definition and treatment of physical and mental health in cross-cultural perspective. Strategies for coping with illness in literate and nonliterate, Western and non-Western societies. Frankel

Anth 335. (Rel 335) Religion, Symbolism and Cosmology (3)
How human experience is mediated through the use of symbols. Religious and cosmological systems in cross-cultural perspective. Frankel

Anth 339. Seminar in Anthropology (3)
Topics in anthropology. Varying semester to semester: human evolution, politics and law, introduction to linguistics, human use of space, anthropology of deviance. May be repeated for credit. Frankel, Gatewood

Anth 363. Kinship, Marriage and Descent (3)
Kinship as the central insitution in primitive social organization. Variations in definition and regulation of marriage and descent in cross-cultural perspectives. Critiques of Murdock, Levi-Strauss, and Fortes. Soc 364 recommended in conjunction with this course. Gatewood

Anth 376. Mind, Self and Culture (3)
Concepts and methods of studying relations between the individual and the sociocultural milieu. National character, basic and model personality structures, cross-cultural studies of cognition, ethoscience, and ethnosemantics. Soc Psy 135 and 307 recommended in conjunction with this course. Gatewood

Social Psychology

SPsy 21. (PSYC 21) Social Psychology (3)
Theories, methods of investigation, and results of research in social psychology with emphasis on psychological processes in social behavior, social attitudes, group behavior and social interaction.

SPsy 109. (PSYC 109) Adulthood and Aging: Social and Psychological Perspectives (3)
Psychological, sociological and other social science approaches to the latter two-thirds of the life span. Age stratification and distribution patterns, attitudes to aging, social behavior of older adults, widowhood, issues of retirement and use of leisure time. Blank, Hyland

SPsy 121. Social Psychology of Small Groups (3)
Study of interpersonal behavior in groups. Survey of relevant theories and empirical research. Rosenwein

SPsy 135. Human Communication (3)
Processes and functions of human communication in relationships and groups. Rosenwein

SPsy 307. Attitudes, Attributions, and Actions (3)
Social perception and cognition as studied in current social psychology. Persuasion, conformity, prejudice, stereotypes, and other social processes in relation to attitude formation and change. Anth 376 and Soc Psych 135 recommended in conjunction with this course. Blank

SPsy 308. Seminar in Social Psychology (3)
Intensive consideration of selected topics in current theory and research in social psychology. The subject matter varies from semester to semester, and includes such topics as the social psychology of education, the applications of perception and learning theory to social psychological problems, the social psychology of science, and the social environment of communication. May be repeated for credit.

SPsy 312. Interpersonal Behavior in Small Groups (3)
Intensive consideration of theoretical and methodological issues in the analysis of the development of small groups. Rosenwein

SPsy 317. Contemporary Social Psychology (3)
Study of and practice in writing, planning and editorial functions of *Contemporary Social Psychology*, a national and international publication. Rosenwein and Blank, editors of CSP

SPsy 321. Social Psychology of Developing Adults (3)
Approaches to social and personality aspects of adulthood and aging. Application of a lifespan developmental model and methodology to selected specific issues and current social psychological topics. Prerequisite: one social psychology or psychology course, or consent of the department chairperson. Blank

SPsy 323. Violence in the Family (3)
Dynamics and consequences of domestic violence: individual, social, and cultural factors. Herrenkohl

SPsy 333. (Govt 333) Social Psychology of Politics (3)
Political behavior viewed from a psychological and social psychological perspective. Rosenwein

SPsy 391. Evaluation Research (3)
Application of social research methods of evaluation of the effectiveness of social programs. Measurement, research design, criteria of effectiveness and decision making. Prerequisite: SR 111 or 112 or consent of department chairperson. Herrenkohl

SPsy 392. Social Psychology Research Seminar (3)
Advanced seminar in social psychological research methods: evaluation research and experimental social psychology. Recommended preparation: SR 111 or 112, or Psych 113 and 114, or consent of the department chairperson. May be repeated once for credit.

Sociology

Soc 5. Introductory Sociology (3)
Social organization, stability and conflict, structure and function, and processes of social change in society.

Soc 65. Contemporary Social Problems (3)
Studies of major problems facing contemporary society. McIntosh

Soc 123. Sociology of Social Welfare (3)
Development of social welfare and human service systems in different societies, especially the United States. Issues in contemporary social welfare policy; specific service institutions (e.g., child welfare and mental health); and the role of social work and other helping professions. Lasker

Soc 135. Medicine and Society (3)
Health, illness, and the health profession from the sociological perspective. Social epidemiology, social psychology of illness, socialization of health professionals, organization of health care, patient-professional relationships and ethical issues in medical care.

Soc 141. Social Deviance (3)
Analysis of deviant social systems, supporting factors maintaining them, and societal responses to deviant roles and collectivities. McIntosh

Soc 325. (Hist 325) American Social History, 1607-1877 (3) fall
Social change from early agrarian communities to beginnings of industrialism, emphasizing socio-economic class, family structure, and treatment of women and minority groups.

Soc 326. (Hist 326) American Social History Since 1877 (3) Spring
Changing role of women, minority groups, and the family during the industrial era. Development of the modern class structure and the impact of the welfare state.

Soc 327. Health Policy Analysis (3)
Key issues in health policy: cost containment, quality control, preventive health practices, and distribution of health responses. Roles of government, industry, health professionals, and consumers in policy determination. Lasker

Soc 333. Sociology of Aging (3)
Residential patterns, social policies and services for the aged. Alternative political strategies, health programs, living arrangements and workplace choices considered. The changing roles of the elderly in American and other societies, and the special problems they face. Impact of changing age structure. Lasker

Soc 341. Women and Health (3)
Relationships of women to the medical system. Influence of medicine on women's lives and the impact of the women's movement on health care. Lasker

Soc 364. Lifestyle and the Family (3)
Historical development of families in the U.S. and issues faced by contemporary American families, including parenting, combining work and family, and divorce and remarriage. Anth 363 recommended in conjunction with this course. Stinson

Soc 370. Juvenile Delinquency (3)
The development of delinquent behavior within its social context; an analysis of delinquent gangs and subcultures and the variable patterns of antisocial activity; and the evaluation of institutional controls and treatment of the problem. McIntosh

Soc 373. Seminar in Sociology (3)
Intensive consideration of selected topics in contemporary theory or research in sociology. The subject matter varies from semester to semester. May be repeated for credit.

For Graduate Students

The department offers a master's degree program in social relations. This thirty-credit program offers both further preparation for an advanced degree and training for nonacademic careers.

Students may choose to pursue a "health and aging" specialization in our graduate program. After completing the basic theory and methods courses required of all graduate students, the student will take a set of core courses in health and aging and participate in an internship. All graduate students complete the program with a thesis.

Other options that focus on the research interests of specific faculty members are also available. In conjunction with the Center for Social Research the department offers many opportunities for research experience. For further information students should contact the department chairperson.

SR 411. Advanced Research Methods (3) fall
A basic course given in research theory and methods. Consideration given the nature of theory, hypotheses testing, the definition of variables and methods of measurement. Herrenkohl

SR 412. Practicum in Research Methods (3) spring
Laboratory in the design and execution of research. Includes class project. Prerequisite: SR 411.

SR 413. Fieldwork in Social Relations (3)
Supervised work experience in a variety of field settings, e.g. hospital, public and private social service agencies and organizations.

SR 414. Survey Research (3)
Examination of survey methods, sample design, interview design, training of survey personnel, data management and analysis.

SR 416. (Educ 416) Quasi-Experimentation and Program Evaluation (3) spring
Social science research methods for non-laboratory settings. Examination of quasi-experimental research designs, threats to validity, possible controls, and uses in social program evaluation. Non-mathematical presentation. Knowledge of elementary statistics assumed. Campbell

SR 461. Seminar in Social Relations (1-4)
Topics in social relations: anthropology, sociology and social psychology. Topics vary.

SR 470. Social Theory (3) fall
Major trends in social science theory in historical context. Comparison of the major theoretical perspectives with an emphasis on underlying philosophy and the development of critical capacities in students.

SR 471. Special Topics (1-3)
Intensive study in an area of social relations that is appropriate to the interests and needs of staff and students.

SR 472. Special Topics (1-3)
Continuation of SR 471.

Sociology

See listings under Social Relations.

Spanish

See listings under Modern Foreign Languages.

Special Education

See listings under Education.

Speech and Theater

Associate professors. Jeffrey Milet, M.F.A. (Yale); Augustine Ripa, M.F.A. (Northwestern), *head.*
Assistant professors. Annie Laurie Wheat, M.F.A. (Georgia); Dina Wills, Ph.D. (Oregon).
Resident designer. Bruce Candlish, M.F.A. (Penn State).

To study theatre is to examine its many internal disciplines. Acting and directing combine with design, techniical theatre, dramatic literature and theatre history to form the body of our art. Students may pursue general theatre studies or focus on particular areas such as performance or design. They may major in theatre, minor in theatre or speech or participate strictly in our production program. Students may even complete a minor in speech or theatre from outside the College of Arts and Science.

The bachelor of arts degree in theatre is granted after at least thirty one credit hours of study. Because we believe that undergraduate theatre education should be broad based with an emphasis on diversity of experience, students are encouraged to take a variety of courses outside the major. Some students complete double majors. Those with the talents and aspirations for a career in theatre have gone to graduate schools offering intense, pre-professional training. Recent majors who have not pursued a theatrical career have gone from our program directly into careers in business, social services, sales. Speech and theatre studies are excellent preparations for vocations in which self presentation is important, such as law. The problem solving, analytical and interpersonal skills gained from these studies are applicable across a wide range of careers. An understanding and appreciation of the complex art of the theatre will enrich a lifetime.

In addition to its academic courses, the division sponsors an active production program in which students, faculty and guest artists collaborate. Our main performance facility is the Wilbur Drama Workshop, a large, classic black box theatre. The core of our work in this space is dedicated to productions featuring primarily student actors directed by faculty or guest artists. When possible, a highly qualified student may direct or design in the main space. In addition to our own productions, we regularly invite outside professional performers and ensembles to work with us and perform. We also operate a separate lab theatre designed specifically for student experimentation. In cooperation with the College of Engineering and Applied Science, we operate a program in theatre technology research in which selected students may participate through directed studies courses. The availability of valuable hands-on experience and the very close working relationships developed between students and faculty uniquely characterize the division of speech and theatre.

Students interested in designing a major in theatre or a minor in theatre or speech should consult with the division head. Experienced theatre students with questions regarding accurate placement in any theatre course should, likewise, consult with the division head.

Theatre Major

Through the selection of appropriate electives, students may concentrate their major in one of these areas:

ACTING/DIRECTING
DESIGN/TECHNICAL THEATRE
GENERAL THEATRE STUDIES

The major in theatre consists of 31 hours distributed as follows:

Coursework required of all majors, 16 hrs

Thtr 117	Theater History (3)
Thtr 123	Dramatic Literature (3)
Thtr	Acting (3) any appropriate level
Thtr	Design (3) scenic, lighting or costume
Thtr 144	Basic Directing (3)
Thtr	Senior Study (1)

Electives, 15 hrs
Not more than two theatre electives may be below 100 in number.

Recommended electives from other departments:
The departments of Art and Architecture, Classics, English, Modern Foreign Languages, Music and others all offer courses of value to a theatre major or minor. Consult with your advisor about scheduling these.

Theatre Minor

The minor in theatre consists of 15 credit hours selected in consultation with a departmental advisor. Through the careful choice of courses students may create emphases in Acting/Directing, Design/Technical Theatre, or General Theatre Studies.

Speech Minor

A minor in speech consists of 15 credit hours chosen from among the following:

Spch 60	Fundamentals of Speech Communication (3)
Spch 130	Public Speaking (3)
Spch 137	Oral Interpretation (3)
Spch 138	Voice and Articulation (3)
Spch 331	Business and Professional Speaking (3)
Thtr	Acting (3) (any appropriate level)

Students will arrange a minor program in speech with an advisor assigned by the division.

Departmental Honors

The exceptional theatre student may elect to pursue departmental honors in the senior year. This student must have a gpa of 3.3 in all theatre courses presented for the major. In the fall of the senior year the student, with faculty supervision, elects a special project in a particular area of theatre. This may take the form of preparing to direct a play, researching a role to be performed, preparing a design presentation or researching in an area of theatre scholarship in preparation for the writing of a substantial report. In the spring of that year the report or project would be executed. The student would enroll in two three credit honors courses, which would replace the Senior Study requirement. Students graduating with departmental honors would have a minimum of 36 credit hours of theatre courses.

The Acting Sequence

Students with little or no prior acting experience should elect Theatre 11, Introduction to Acting, as their first course. Students with some prior acting experience should consult with the division head for accurate placement and waiver of the Theatre 11 prerequisite.

Courses in Speech

Spch 60. Fundamentals of Speech Communication (3)
The basic principles of communication: the informative speech, small group communication process, principles of persuasion, effects of mass communication. Two speeches, term paper, group project.

Spch 130. Public Speaking (3)
Practice in planning and presenting speeches of all types, e.g. informative, persuasive, entertaining. Five or six speeches per student.

Spch 137. Oral Interpretation (3)
The analysis and oral presentation of various types of literature: Prose fiction, poetry, drama, non-fiction.

Spch 138. Voice and Articulation (3)
Voice production and articulation. Recommended for students of acting.

Spch 331. Business and Professional Speaking (3)
The principles of oral communication as applied to business and professional situations. Business presentations, small group interaction and presentation, interpersonal communication in the business setting. Prerequisite: junior or senior standing.

Courses in Theatre

Thtr 1. Introduction to Theater (3)
Elements of the theatrical experience. The foundations of theater. Examination and discussion of plays.

Thtr 11. Introduction to Acting (3)
Discussion of text. Basic exercises and techniques. Preparation for scene study. Recommended for students with little or no prior experience.

Thtr 15. Introduction to Technical Theater (3)
Stagecraft and drafting for the theater. Concepts in theater technology. Theatrical materials and methods.

Thtr 61. Theater Production (1-3)
The role of the production team. Its relationship to the theatrical event. General concepts and techniques applied to actual productions. May be repeated for credit.

Thtr 111. Theater Sound (1)
Techniques, materials, and methods of designing sound for theatrical production.

Thtr 113. Stage Lighting (3)
An introduction to the art and practice of lighting for the stage.

Thtr 115. Scene Design (3)
An introduction to the art of the scenic designer. History of design for the theater. Materials, methods and techniques.

Thtr 116. Advanced Technical Theater (3)
A continuation of Theater 15. Advanced, drafting, problem solving, stagecraft, rigging, materials and techniques. The role of the technical director. Prerequisite: Thtr 15.

Thtr 117. Theater History (3)
Historical survey of western theater from origins to present.

Thtr 123. Dramatic Literature (3)
Western dramatic literature. Emphasis on major authors, genres, periods.

Thtr 144. Basic Directing (3)
Introduction to the theatrical director's art. Scene work. Prerequisites: Thtr 1 and any acting course, or consent of division.

Thtr 147. Acting Early Modern Drama (3)
Elements of characterization through scene study. Emphasis on work of early modern dramatists, e.g. Ibsen, Strindberg, Chekhov and others. Prerequisite: Thtr 11 or consent of division.

Thtr 148. Acting Contemporary Drama (3)
Elements of characterization through scene study. Emphasis on works of recent dramatists, e.g. O'Neill, Williams, Miller and others. Prerequisite: Thtr 11 or consent of division.

Thtr 151. Costume Design (3)
The history and development of theatrical costuming. Wardrobe and its relationship to art and culture.

Thtr 161. Theater Design and Technology (3)
Theater environments, equipment systems and acoustics. Functions and ethics.

Thtr 175. Special Projects (3)
Theatrical topics of current or special interest, e.g., mime. Can be repeated for credit as title varies.

Thtr 181. Theater Management (3)
Concepts, techniques and practices related to managing the theatrical enterprise.

Thtr 185. Production Seminar (3)
Practicum in various approaches to theater production, e.g. ensemble. Prerequisite: consent of the division head. Can be repeated for credit as title varies.

Thtr 214. Advanced Lighting (3)
Continuation of Theater 113. Lighting design for various performance forms. Practical experience. Prerequisite: Thtr 113.

Thtr 216. Advanced Scene Design (3)
Continuation of Theater 115. Advanced design problems and techniques. Practical experience. Prerequisite: Thtr 115.

Thtr 244. Acting Styles (3)
Acting problems in non-realistic drama, e.g. Shakespeare. Prerequisite: a 100-level acting course, or consent of division.

Thtr 245. Advanced Directing (3)
Continuation of Theater 144. Directorial approach. Supervised practical experience. Prerequisite: Thtr 144.

Thtr 271. Playwriting (3)
Techniques of the dramatist. The playwright's creative process. Practice in creating dramatic forms.

Thtr 351. Advanced Special Projects (1-3)
Independent study in theater. Prerequisite: consent of the division head. Can be repeated for credit as title varies.

Thtr 361. Research in Theater Technology (1-3)
Solving technological problems in theater. Application of new technologies. May be repeated for credit. Prerequisite: consent of division head.

Technology, Interdisciplinary Courses

See listings under Science, Technology and Society.

Theater

See the course descriptions for Speech and Theater.

Urban Studies

Urban Studies Committee. David Curtis Amidon, Jr., M.A. (Penn State), *lecturer in urban studies and director of urban studies;* Nicholas Adams, Ph.D. (N.Y.U.), *associate professor and chairperson of art and architecture;* Frank T. Colon, Ph.D. (Pittsburgh), *professor of government;* Barbara Frankel, Ph.D. (Princeton), *associate professor of social relations;* Warren A. Pillsbury, Ph.D. (Virginia), *associate professor of economics;* Roger D. Simon, Ph.D. (Wisconsin), *associate professor of history;* Ivan Zaknic, M.Arch. and Urban Planning (Princeton), *associate professor of architecture.*

This is an interdepartmental major program intended for students who seek a broad background in the social sciences and for those with career interests in such fields as business or law, and such specialized areas as city management, architecture and urban planning, human relations, and the helping professions.

Instruction focuses on the process of urbanization, the problems and opportunities arising therefrom, the relationship between cities and economic growth, and existing and proposed public policies relating to cities.

A minimum of 33 credit hours is required, apportioned among two levels of study. Substitutions are possible with approval of the director, who advises all those with majors and minors in urban studies. The director's office is located at 232 Chandler-Ullmann Hall.

Undergraduate Major

I. required preliminary courses (9 credit hours)

US 61	The Study of Urbanization (3)
US 62	Contemporary Urban Issues (3)

one of the following two research methods courses

Govt 21	Introduction to Research Methods (3)
Eco 145	Statistical Methods (3)

II. elective courses (24 credit hours)

Any course may be elected from among the following:

Anth 128	Urban Ethnology (3)
Anth 151	Utopias and Alternative Communities (3)
Arch 207	Renaissance Architecture (3)
Arch 213	The City (3)
Eco 312	Urban Economics (3)
Eco 337	Transportation and Spatial Economics (3)
Govt 77	Urban Politics (3)
Govt 360	Public Administration (3)
Hist 333	American Urban History to 1885 (3)
Hist 334	American Urban History, 1880 to Present (3)
US 363	Philadelphia: Development of a Metropolis (3)

Up to two courses may be elected from among the following:

Arch 210	20th-Century Architecture (3)
Eco 354	Public Finance: State and Local (3)
Govt 331	Government and Law Internship (3)
Hist 326	American Social History Since 1877 (3)
US 125	American Ethnic Groups (3) (US 321, 324, 326 or 328 may be offered instead of US 125)
US 371/372	Special Topics (3-6)

Participants in off-campus programs, such as the Philadelphia or Washington semesters, may receive credit for up to three elective courses, depending upon the content of those courses, but they must also complete at least five courses in the first group of electives above.

Urban studies minor. The minor consists of US 61 and five additional courses from an approved list for a total of eighteen credit hours.

Undergraduate Courses

61. The Study of Urbanization (3) fall
Introduction to the study of cities. Emphasis on sources of economic vitality, especially entrepreneurialism, and on urban sociology. Some lectures on Bethlehem and Lehigh Valley history for illustrative purposes.

62. Contemporary Urban Issues (3) spring
Analysis of problems, typically including planning, housing, and finance, with strong emphasis on twentieth-century New York City.

125. American Ethnic Groups (3) fall, 1988
Immigration to the United States; persistence of cultural differences over generations; patterns of conflict and accommodation; assimilation; ethnic politics; emphasis on white Euro-American nationality groups; with some attention to Afro-, Hispano-, Asian-, and native Americans. Amidon

321. White Protestant Americans (3) fall, 1987
Cultural and religious origins of the historically dominant ethnic group in the United States; rise and decline of national Anglo-Protestant urban elite; persistence of regional and nonelite subcultures; "Wasp" stereotypes and anti-Protestant themes in American culture. Amidon

324. The Irish in American Society (3) spring, 1988
Cultural, economic and political experience of a major white ethnic group in the United States; Irish Catholics vs. Scotch-Irish Protestants; immigrant poverty; priests and prelates, ward healers and big-city bosses; Irish themes in American literature, humor, and media culture; Irish radicalism. Amidon

326. The American Italian Community (3) spring, 1987
European background of Italian emigration; patterns of first-generation experience in the United State; distinctive values, folkways, and institutions; the "Mafia"; political behavior; upward mobility and assimilation; achievements of outstanding individuals; interaction with general American culture. Amidon

328. The American Jewish Community (3) spring, 1989
Historical and sociological perspectives on the experience of an important minority in the United States; communal institutions and social patterns; orientation toward achievement and secular success; Jewish influences in American culture; anti-Semitism, acceptance, and survival as a distinct subculture. Amidon

363. Philadelphia: Development of a Metropolis (3) fall
Philadelphia as an early experiment in the deliberate creation of a new community; the rise of the port; industrialization and immigration; creation of a hinterland and competition with rival centers; upper-class family continuity; religious life and institutions; political history.

371, 372. Special Topics (3-6)
A seminar on a topic of special interest in urban studies. Prerequisite: consent of the program director.

"About 1904—Conradi." Swift's Dressed Pork and Posten's Transfer Co. Stable were two of the businesses near the Union Depot on Bethlehem's South Side.

VI.

An Overview from Past to Present

Lehigh University is independent, nondenominational, and coeducational.

Founded in 1865 as a predominantly technical four-year school, the university now has approximately 4,400 undergraduates within its three major units—the College of Arts and Science, the College of Business and Economics, and the College of Engineering and Applied Science—and approximately 1,800 students enrolled in graduate programs offered through the Graduate School in these colleges and in the College of Education. There are undergraduates from nearly every state and U.S. territory and more than forty foreign nations. Although the majority of students are from the Middle Atlantic region, the Alumni Admission Outreach Program is expanding Lehigh's enrollment from distant points.

The university is primarily situated on the north slope of South Mountain overlooking Bethlehem, Pennsylvania. Sayre Park, the wooded refuge located toward the top of the mountain, is the setting for many living groups. The residences are reached via winding private roads. Many residential units on the campus afford students who live in them a panoramic view of the Lehigh Valley. It can be said at Lehigh that, like the show tune, "on a clear day you can see forever." The Appalachians are visible across the expanse of valley, with an especially good view afforded from The Lookout. The campus at its highest point is 971 feet above sea level.

Because of the unique setting, interesting architectural treatments are possible. Several dwellings and academic buildings are entered from upper levels, such as the third floor.

A substantial portion of the upper level of the campus is maintained as a nature preserve. The preserve includes flora indigenous to the area and wildlife in its natural habitat, including deer, squirrels, chipmunks, raccoons, and birds.

Besides the South Mountain Campus, the university has extensive athletic fields and facilities on the Murray H. Goodman Campus, just two miles or so to the south in the Saucon Valley. The university acquired the Hilltop Campus at the end of 1986. It links the South Mountain and Murray H. Goodman campuses and bringing total land holdings in Bethlehem to 1,600 acres, nearly double the former total.

Besides its Bethlehem facilities, the university also operates Stone Harbor Marine Laboratory, near Stone Harbor, N.J.

The institute has laboratories and dormitory space for students. It is concerned with the preservation and improvement of the coastal environment.

The board of trustees and university officers have established and enforce policies designed to preserve the natural beauty of the campus. It is their contention that the environment in which the young adult university student pursues knowledge can make the total educational experience more meaningful, and that the ideal environment is separate and unique from the distractions of the non-academic community.

There are approximately 375 members of the faculty, teaching a total of more than 2,000 course titles (not all of which are offered every semester). Among faculty members who are tenured and to whom the university has a permanent commitment, nearly all hold the doctorate degree (typically Ph.D. or Sc.D.).

In total, there are more than 2,000 employees of the university, making it the second-largest employer in the community.

History and Purpose

The principal author of the brief history of Lehigh University that follows, Dr. W. Ross Yates, holds the bachelor of arts and master of arts degrees from the University of Oregon, in his native state. He received the doctor of philosophy degree from Yale University and studied in France on a Fulbright Scholarship. He joined the Lehigh staff in 1955 and served as dean of the College of Arts and Science from 1963 to 1972. Today he is professor emeritus of government, and lives in Oregon.

When the sound of the last cannon of the Civil War died away, statesmen, educators, and industrial pioneers marshalled the victorious forces of the North and turned their attention to education. They wanted to increase the number of trained scientists, engineers, and other skilled people so they could transform the vast natural resources of the country into a strong and independent national economy.

Asa Packer was one of the industrial pioneers. He built the Lehigh Valley Railroad and controlled a coal-mining empire in the mountains of eastern Pennsylvania. He knew, as did many others, that a strong national economy depended on more than technical skills. It needed above all people broadly educated in the liberal arts and sciences—people who could combine practical skills with informed judgments and strong moral self-discipline. He kept this in mind when founding and endowing Lehigh University.

The site that Packer chose for his university was a railroad junction across the Lehigh River from Bethlehem, a community founded in 1741 by Moravian missionaries. William Bacon Stevens, Episcopal bishop of the Diocese of Pennsylvania and the first president of the university's board of trustees, in 1869 described the origin of the university as follows:

"In the fall of 1864 an interview was requested of me by the Hon. Asa Packer, of Mauch Chunk (now Jim Thorpe), Pa. He came to my house in Philadelphia, and said that he had long contemplated doing something for the benefit of his State, and especially of the Lehigh Valley. From that valley he said he had derived much of the wealth which GOD had given to him, and to the best interests of that valley he wished to devote a portion of it in the founding of some educational institution, for the intellectual and moral improvement of the young men of that region.

"After conversing with him a little while, and drawing out his large and liberal views, I asked him how much money he purposed to set aside for this institution, when he quietly answered that he deigned to give $500,000. At the time of this interview no one in this country, it is believed, had offered in a single sum such an endowment for a literary institution. It was the noblest offering which an American had ever laid on the altar of learning, and more than equaled many royal donations which have carried down the names of kings as patrons of European universities.

"Filled with profound emotions at the mention of such a gift for such an object, I asked the noble donor what specific plans he had dreamed in his own mind in reference to it. His reply was, 'I am not much acquainted with these matters, but you are, and I want you if you will to devise a plan which I can put into effective operation.' I told him that I would make the attempt. I did so. I drew up the outline sketch of such an institution as I thought would give the largest results for the means used, and submitted it in a few weeks to his inspection.

"He examined it with the practical judgment and business habits with which he deals with all great questions, and adopted the scheme as the basis of his future university.

"The first meeting of the Board of Trustees, selected by Judge Packer, met at the 'Sun Hotel,' in Bethlehem, July 27th, 1865, and began to organize the work before them."

The trustees followed several principles in setting up the university. One was that of combining scientific and classical education. They considered both to be practical. The principle carried forward an ideal of the great 17th-Century Moravian educator, John Amos Comenius. A motto taken from the works of Francis Bacon was used to summarize this principle, namely, *Homo minister et interpres naturae*—man, the servant and interpreter of nature, to use a free translation. That motto lives on at Lehigh, being an element in the university seal.

The trustees chose as first president a man whose education and habits expressed this principle, Henry Coppée. They established five schools, including a school of general literature in addition to four scientific schools of, respectively, civil engineering, mechanical engineering, mining and metallurgy, and analytical chemistry.

Another principle upon which the trustees insisted was that of keeping the size of the student body proportionate to the abilities of the faculty to teach them well. The university would admit only as many freshmen each year as it could be assured of providing with the highest quality of education. In the 19th Century the total enrollment never exceeded several hundred students; the size has increased significantly in recent decades, along with the number of faculty members.

The trustees also insisted that Lehigh was to be nondenominational and would have an admission policy based on merit. Competitive examinations were held for applicants for admission. From 1871 to 1891 no tuition was charged, but the national financial crisis at the turn of the century decimated the value of the Lehigh Valley Railroad stock that Packer had given to Lehigh, which was the principal source of income.

At first the student body was entirely male. The contemporary ideological climate would permit nothing else. But around 1916, women were admitted to graduate programs. In 1971, the university opened its undergraduate program to them as well. Today men and women applicants are considered on an equal basis, and in the class that entered in 1986 more than 35 percent of the students were female.

From the first, the students were serious-minded. In 1924, Catherine Drinker Bowen, daughter of president Drinker and later a famous biographer, published a brief *History of Lehigh University*, in which she commented:

"Ask any college professor which brand of boy he would prefer to teach, the cigarette brand or the flannel shirt variety. Right here we offer ten to one the flannel shirts . . . Lehigh still holds to the emblem of the flannel shirt—long may it wave! Engineers come to college to work. A writer in the *Syracuse Post* in 1895 spoke truthfully when he said, 'From the first, Lehigh's characteristic has been her earnestness. It is the boast of her graduates, the inspiration of her students. Men go there to learn to take a useful part in the economy of life'."

The university community was constantly infused with new faculty and students determined to renew and rework the original principles in the light of changing times. The students' ambition and zeal bore fruit; as alumni they carried the university's educational goals into the work of nation-building. And, having received, they gave to perpetuate Lehigh's work of service.

Today, Lehigh University still adheres to Asa Packer's goal of a liberal and scientific education for practical service. Faculty and students work to maintain high quality in instructional programs. Generous support from individuals, foundations, industry, and government help Lehigh to retain

high quality of education and faculty while keeping tuition as low as possible. (Tuition covers only a part of the cost of a Lehigh education.)

Presidents of the University

The presidents of Lehigh University are described and their achievements cited in the following paragraphs. The years in parentheses are those served in the presidency.

Henry Coppée (1866-1875). Coppee served as a railroad engineer in Georgia, a captain in the Army during the Mexican War, and taught at West Point and at the University of Pennsylvania before becoming first president in 1866.

Much building was done on the new university campus. A Moravian church on Packer Avenue was remodeled into Christmas Hall; a house for the president was erected on campus; and Packer Hall, the university center, was built.

Coppee lectured in history, logic, rhetoric, political economy, and Shakespeare.

John McDowell Leavitt (1875-1880). Leavitt was an Episcopal clergyman who graduated from Jefferson College and taught at Kenyon College and Ohio University. During his incumbency, the university was divided into two schools, General Literature and Technology. As of 1876, a student could receive two engineering degrees by taking a longer course, and beginning in 1877 the master of arts, doctor of philosophy, and doctor of science degrees were established.

Linderman Library rotunda was completed in 1877. Asa Packer died in May, 1879, and Founder's Day was held in his honor the following October.

Robert Alexander Lamberton (1880-1893). Lamberton, a graduate of Dickinson College, practiced law in Harrisburg, Pa., and was a university trustee when asked to become president. During his administration, students and the community witnessed the first Mustard and Cheese dramatic presentation.

A gymnasium (now Coppee Hall) was erected, and Chandler Chemistry Laboratory was built, now known as Chandler-Ullmann Hall. Lehigh was also building its reputation for academic excellence; the mechanical engineering department was established in 1881 and the Lehigh chapter of Phi Beta Kappa was founded in 1887.

Thomas Messinger Drown (1895-1904). Drown studied medicine at the University of Pennsylvania and went abroad to study chemistry. Thereafter he was professor of chemistry at Lafayette College. In 1895 he assumed the presidency of Lehigh and was greatly interested in furthering the university's development as a technical school.

His first years were difficult ones because the Panic of 1893 decimated the university's stock holdings in the Lehigh Valley Railroad. Nevertheless, Lehigh managed to grow in enrollment, academics, and in physical plant. Williams Hall was completed. The curriculum leading to a degree in arts and engineering was established, as was the department of zoology and biology. New curricula were adopted in metallurgical engineering, geology, and physics.

Drown died in office in 1904. Professor William H. Chandler became acting president.

Henry Sturgis Drinker (1905-1920). Drinker, an 1871 Lehigh graduate, was the only university alumnus ever to become president. In 1907, the alumni endowment fund began, the *Lehigh Alumni Bulletin* was first published in 1913, and the Alumni Association was incorporated in 1917.

Drinker, besides being a lawyer, was a mechanical engineer and had been largely instrumental in solving the problems of constructing the two-mile-long Musconetcong Tunnel, an engineering feat that made possible a railroad line between Easton, Pa., and New York City. He started a tradition of businesslike management of university affairs.

During Drinker's years, more buildings were completed: the original section of Fritz Engineering Laboratory, Drown Hall, Coxe Mining Laboratory, Taylor Hall, Taylor Gymnasium and Field House, Taylor Stadium and Lamberton Hall. Drinker's interest in horticulture led to the planting of many rare trees and plants.

A teacher's course and business administration course were begun in 1909 and in 1918 the university was divided into three colleges, liberal arts, business administration, and engineering—the roots of the colleges of today. Army ROTC wasestablished in 1919.

Drinker's daughter, Catherine Drinker Bowen, went on to become a historical writer of note. Her experiences as the daughter of a Lehigh president and occupant of the President's House are recorded in *Family Portrait* (Atlantic Little-Brown).

Drinker resigned in 1920 and Natt M. Emery, vice president, served as chief executive officer until 1922.

Charles Russ Richards (1922-1935). Richards took office in 1922. During his presidency, the first graduate degrees were awarded to women. Lehigh faced a shortage of students from 1929 to 1936 as a result of the Depression, but the newly established office of admission, as well as university scholarships, fellowships, and deferred tuition payments, helped to ease the shortage.

Changing concepts of education were evident in several newly organized academic offerings: philosophy, music, psychology, journalism, history, and fine arts. The majors system was instituted as were the senior comprehensive examinations in the Arts College. The placement bureau, a public relations office, and a student health service were organized.

The Alumni Memorial Building—a memorial to the Lehigh alumni who served in World War I—and Packard Laboratory both were completed in 1925. In the same decade, a major addition to Linderman Library also was completed.

Clement C. Williams (1935-1944). Williams, a civil engineer, was president during an era of unprecedented alumni support. Undergraduate enrollment rose to an all-time high, passing 2,000 in 1938. Richards and Drinker residential houses, and the Ullmann building adjoining the Chandler Chemistry Laboratory, were built. Grace Hall, the first arena-type facility of any size on campus, was completed in 1940, the gift of Eugene G. Grace, an 1899 graduate, who headed the board of trustees. A Graduate School implemented the programs in the three colleges. Williams retired in 1944, and the university was without a president for approximately two years.

Martin Dewey Whitaker (1946-1960). Dr. Whitaker, who had been director of the Atomic Energy Commission Laboratory at Oak Ridge, Tenn., and had worked in developing the atomic bomb, faced the responsibility of helping the university community readjust to peacetime conditions after World War II.

During his time as president, Lehigh's assets nearly tripled; the endowment more than doubled to $18 million. Many buildings were renovated, and the Dravo House and McClintic-Marshall House residence halls were built. The faculty increased in number by 75 percent and the first endowed distinguished professorships were established.

The Centennial development program was begun in 1959. It raised more than $22 million for faculty salaries and construction that later included Whitaker Laboratory.

An extensive renovation and enlargement project associated with Packer Hall was undertaken in 1957, and, upon completion in 1958, the building became a university center.

Academically, during the Whitaker years 120 departments offered the master's degree and twelve the doctor of philosophy.

Whitaker died in office.

Harvey A. Neville (1961-1964). Dr. Neville was the only faculty member ever elected president. His association with the university began in 1927 as an assistant professor of chemistry. During his three-year term as president, the first phase of the Saucon Valley athletic complex was completed, and Sayre Field was opened atop South Mountain. The Center for Information and Computing Science was established.

Dr. Neville, a strong supporter of research who fostered its growth on the campus, died in 1983.

Deming Lewis (1964-1982). Willard Deming Lewis became president after a distinguished career as a space engineer and research administrator.

Dr. Lewis comes from a remarkable family that traces its American roots to William Lewis, an Englishman who settled in the Massachusetts Bay Colony in 1640. His great-grandfather and grandfather were presidents of the Lewis Manufacturing Co., a textile firm in Walpole, Mass. Willard Lewis, Deming's father, moved to Augusta, Ga., and eventually became owner of Riverside Mills there.

Deming was admitted to Harvard at age fifteen, but his mother thought him too young to attend. So he waited and entered Harvard at age sixteen, eventually receiving three degrees there, as well as two degrees from England's Oxford University, where he was a Rhodes Scholar in advanced mathematics. At Harvard, Lewis worked with Ted Hunt, the father of high fidelity, writing the equations describing a stylus sliding through a warped groove.

In 1941, Lewis joined Bell Telephone Laboratories, and in 1962 he was one of four executives who initiated Bellcomm, Inc., in Washington, D.C., which engineered systems for the Apollo project that placed the first man on the moon.

Lewis, a Bethlehem resident, holds thirty-three-U.S. patents on such devices as microwave antennas and filter and digital error detection systems.

During the Lewis administration, undergraduate women were admitted in 1971, and the university's visiting committees were established in 1964. New programs included majors in natural science, biology, social relations, geological sciences, environmental science and resource management, and religion studies. Minors for engineering students in such fields as business, history, and social sciences were begun. Interdisciplinary majors such as computer enginering, computing and information science, applied mathematics, management science, American studies, and many others were instituted. Six research centers and seven institutes were established, including the Biotechnology Research Center.

The first phase of the New Century Fund capital campaign yielded $1.1 million more than its goal of $30 million; the second phase, which brought the campaign to a conclusion in 1985, raised more than $100 million.

Construction included the following: Maginnes Hall; Whitaker Laboratory; Mart Science and Engineering Library; the Central Heating and Refrigeration building; Sinclair Laboratory; the Seeley G. Mudd Building and Neville Hall, Rathbone Hall dining room; thirteen fraternity houses, the Centennial I and Centennial II residential complexes; the Trembley Park student apartment complex; the Saucon Village Apartments complex, completion of the acquisition of the Saucon Valley athletic lands and the construction there of the Varsity House, the squash courts, the Philip Rauch Field House and Stabler Athletic and Convocation Center; and Brodhead House, a six-story residence hall. In addition, the restoration of Packer Memorial Church was completed, as well as a million-dollar renovation of Packard Laboratory. Plans were made for the E. W. Fairchild-Martindale Library and Computing Center.

Dr. Peter Likins (1982-present). Dr. Likins became eleventh president in 1982. Under his guidance Lehigh continues to seek balanced excellence in undergraduate programs while pursuing focused objectives in graduate study and research.

The Likins presidency has been characterized by achievement and action. In 1986, for example, Lehigh completed construction and implementation of its state-of-the-art telecommunications system, a $20-million-plus project. As a result, virtually all university buildings and residential facilities are wired to allow students and faculty maximum access to information and each other via the voice-and-data telecommunications network. Completion of the network approximately coincided with the dedication in 1986 of the E.W. Fairchild-Martindale Library and Computing Center, which affords to the campus community one of the most automated library facilities available anywhere.

Also in 1986, a building adjoining the campus, at 200 W. Packer Ave., was named the Harold S. Mohler Laboratory, honoring the former chairman of the board of trustees. The building has been renovated to accommodate the Lehigh programs in manufacturing systems engineering. The high-tech environment gives students access to the latest technology in robotics. When renovations are completed in 1987, the building will also house the industrial engineering department.

In the fall of 1986, a dedication was held for the Sherman Fairchild Center for the Physical Sciences, an outstanding facility encompassing the renovated 1890s-era Physics Building, the contemporary Sherman Fairchild Laboratory, and a new structure linking the two and providing an imposing entrance to physics facilities. The new building includes a 260-seat auditorium.

Also in 1986, the university purchased research facilities and land from Bethlehem Steel Corp. As a result, the university's existing campuses became contiguous with purchase of what is now called the Hilltop Campus, an area southeast of the main campus and north of the Murray H. Goodman Campus. The acquisition of five buildings and 742 acres at a cost of $18.75 million was the largest real estate transaction in the history of the university. Campus acreage virtually doubled.

Likins led the way in the establishment of the Colonial League in football, effective with the 1986 season. Other schools belonging to the league are Bucknell, Colgate, Davidson, Holy Cross, and Lafayette. The league represents a commitment by participating schools to the principle of "scholar-athletes," students who are primarily concerned with academic work but who also play football. This principle has been a Lehigh tradition. Eventually, the member schools all will play each other every year, while also including Ivy League schools in their schedules. A playoff game with the Ivy League titlist is a possibility.

The university hopes to build by 1988 a new 14,000-seat stadium for football and other sports on the Saucon Valley Campus. Taylor Stadium, on the main campus would be razed.

Under Likins, financial support of the university has grown from around $10 million annually to more than $18 million in both 1985 and 1986. In 1986, 60 percent of alumni made gifts to Lehigh, placing Lehigh just behind first-place Dartmouth and just ahead of Princeton in percentage of alumni making gifts. The three schools are the leaders among Ph.D.-granting institutions for which records are kept on a national basis.

Likins was a prime mover in the establishment in 1984 of the Lehigh Valley Center for Jewish Studies, headquartered at Lehigh and serving private colleges in the area, and the establishment of a chair in Judaica based at Lehigh supported by a major gift from Philip and Muriel Berman.

In recent years, Lehigh established a center in the field of integrated circuits: the Center for Innovation Management Studies, the Center for Chemical Process Modeling and Control, and the Center for International Studies.

The president has expressed the need for additional buildings to accommodate the College of Business and Economics, and the performing arts.

A native of California, Likins is relaxed and informal in his interpersonal dealings and has regular personal contact with undergraduates. A former collegiate wrestler of some note (in 1982 he was named to the National Wrestling Hall of Fame), he and members of his family regularly attend Lehigh athletic events.

Likins was substantially involved in the university's designation as home of the North East Tier Ben Franklin Advanced Technology Center, one of four such centers established by the Pennsylvania legislature. The North East Tier center has assisted dozens of fledgling businesses involved in high-technology fields.

Dr. Likins is a distinguished academic administrator, a seasoned educator in engineering, an expert in spacecraft dynamics and control, an author of textbooks in engineering mechanics, a researcher who continues to add to his substantial list of publications, and a consultant to governments and industry.

He earned the B.S. in civil engineering from Stanford University in 1957, the master of science in civil engineering from Massachusetts Institute of Technology the following year, and the Ph.D. in engineering mechanics from Stanford

in 1965. He joined Columbia as dean of the School of Engineering and Applied Science in 1976 and was named a provost in 1980. Earlier, he was a development engineer at the Jet Propulsion Laboratory of the California Institute of Technology, and subsequently served as professor and later as associate dean of engineering at the University of California, Los Angeles. He is a fellow of the American Institute of Aeronautics and a member of the National Academy of Engineering.

Dr. Likins and his wife, Patricia, have six children and reside in the President's House.

University Campuses

Lehigh University's three campuses are all located in Bethlehem, Pa., and are contiguous with each other. These campuses comprise nearly 1,600 acres.

South Mountain Campus. Lehigh's main academic campus, encompassing approximately 360 acres on the north slope of South Mountain overlooking Bethlehem, is a wooded area where most students attend class and live. This is the original campus of the university.

Murray H. Goodman Campus. During the 1960s, the university acquired extensive acreage in the Saucon Valley area just south of South Mountain. Development of one of the nation's finest collegiate athletic complexes has continued since that time. Holdings now total more than 500 acres and the site includes athletic fields for many sports as well as the 6,000-seat Stabler Athletic and Convocation Center, the Philip Rauch Field House, and the Varsity House locker facility. The campus is named for a major benefactor, Lehigh alumnus Murray H. Goodman, of Palm Beach.

Hilltop Campus. Lehigh acquired in 1986 from Bethlehem Steel Corp. extensive acreage and five buildings located atop South Mountain. Acquisition of the facilities—the largest single transaction in Lehigh history—provides the "connecting link" between the two older campuses, and means that all three campuses are contiguous. The mountaintop purchase includes the 72-acre site atop the mountain and five of the eight buildings there, plus 670 acres in the surrounding area, including a landmark building with a tower that is visible several miles away. Utilization of the facilities will begin with the relocation of the College of Education there in 1987, followed by biosciences, biotechnology and chemical engineering-related programs to the tower building. Another building will house the ATLSS (Advanced Technology for Large Structural Systems) center.

Stone Harbor Marine Laboratory. Besides its Bethlehem campuses, the university also operates Stone Harbor Marine Laboratory, located on a 34-acre site adjoining a coastal salt marsh near Stone Harbor, N.J. The institute has laboratories and dormitory space for students. It is concerned with the preservation and improvement of the coastal environment. Many undergraduates study at the institute.

University Buildings

The university's faculty and students use more than 100 buildings with more than two million square feet of floor space. The date following the name of the building is the year of construction; a second date indicates a major addition.

Most recent of the structures is the E. W. Fairchild-Martindale Library and Computing Center, which was dedicated in 1985. Earlier, the university constructed the Seeley G. Mudd Building and Neville Hall in the chemistry complex (1975), the Philip Rauch Field House (1975), the Sherman Fairchild Laboratory for Solid-State Studies (1976), the Stabler Athletic and Convocation Center (1979), and the Brodhead House high-rise residential facility (1979).

In all, there are approximately 100 academic, residential, and research buildings available for use by the university community.

Campus Landmarks

Alumni Memorial Building (1925). This edifice of Gothic design, housing admission and other administrative offices and those of the alumni association, represents a memorial to the 1,921 Lehigh alumni who served in World War I and the 46 who died. The building was designed by Theodore G. Visscher, Class of 1899, and James Lindsey Burley, 1894.

E. W. Fairchild-Martindale Library and Computing Center (1985). The high-technology building houses science and engineering holdings and a computer center. Construction was made possible by a major gift from Harry T. Martindale, a 1927 Lehigh graduate, and his wife, Elizabeth, daughter of the late Edmund W. Fairchild, founder of a business-publications and communications empire.

Linderman Library (1877). The rotunda was built as a gift to the university by founder Asa Packer as a memorial to his daughter, Lucy Packer Linderman. The rotunda is surrounded except on the south by a major addition constructed in 1929. The building houses more than 20,000 rare books and volumes related to the humanities and social science. The Bayer Galleria of Rare Books, made possible by a gift from Curtis F. Bayer, '35, was dedicated in 1985.

Packer Memorial Church (1887). The church was the gift of Mary Packer Cummings in memory of her father, founder Asa Packer. It was dedicated on Founder's Day, October 13, 1887. The building was designed by the architect Addison Hutton; the stained-glass window over the main door is attributed to Louis Comfort Tiffany.

Observance of the centennial year was planned during 1987.

President's House (1868). This 21-room residence is the home of university presidents. Dr. and Mrs. Peter Likins and family have occupied the dwelling since 1982.

Packer Hall, the university center (1868). When construction of the building began in 1865, a railroad was built to transport stone to the site. The building was extensively renovated and enlarged in 1958.

The building was constructed at the expense of the founder, who vetoed a plan to erect it of brick. "It will be built of stone," Asa Packer responded.

Today the building houses student lounges, a student cafeteria, a snack bar, a faculty dining room, deans' offices, the journalism department, the student radio station, and a bank office and postoffice.

Academic and Research Facilities

Chandler-Ullmann Hall (1883, 1938, respectively). These adjoining buildings formerly were the William H. Chandler Chemistry Building and the Harry M. Ullmann Chemistry Laboratory. Chandler served as acting university president, 1904 and 1905, and taught chemistry from 1871 to 1906. Ullmann served as chairman of the chemistry department.

The department of art and architecture, division of urban studies, and department of psychology, the Marine Geotechnical Laboratory, the office of Lehigh University Art Galleries and the division of speech and theater are located in Chandler-Ullmann.

Christmas-Saucon Hall (1865 and 1872, respectively). Christmas Hall is the university's oldest building. When Asa Packer acquired the South Mountain site for the university in 1865, a Moravian church was being constructed. The newly formed university took over the building and completed it for use in recitations and as a dormitory and chapel. The name Christmas Hall was chosen in keeping with Moravian religious tradition. In 1872, Saucon Hall was constructed a few feet to the east of Christmas Hall. The buildings were connected with the construction of a "hyphen" in 1926. The building houses the department of mathematics and the office of career planning and placement services.

Coppée Hall (1883). The building originally housed classrooms and a gymnasium. It is named in honor of Henry Coppee, first president. Today the building houses the department of modern foreign languages and literature, and The Learning Center.

Coxe Laboratory (1910). Originally a mining laboratory, the structure is named for Eckley B. Coxe, pioneer mining engineer and trustee of the university. The building houses the Materials Research Center.

Drown Hall (1908). The building is a memorial to Thomas M. Drown, president from 1895 to 1904. It is headquarters for the College of Business and Economics until the college moves to its planned new home around 1988.

Fritz Engineering Laboratory (1909, 1955). The laboratory is named for John Fritz, pioneer in the steel industry in the United States and a member of the university's original board of trustees. Fritz provided funds for the original section; a seven-story addition accommodates the university's testing machine, which is capable of applying a five-million-pound load to tension or compression members up to forty feet in length. The hydraulic testing machine is the largest of its kind facility currently in operation in the world. The laboratory is used primarily by the department of civil engineering.

Johnson Hall (1955). The building houses the university health service, the counseling service, the Fraternity Management Association, the chaplain's office, and the motor vehicle office, as well as offices of professors in business and economics. Earle F. "Coxey" Johnson, '07, a director of General Motors Corp. and university trustee, provided funding for the structure.

Lamberton Hall (1907). The structure served as the university commons and dining room until the renovation of Packer Hall in 1958. The building honors the memory of Robert A. Lamberton, third president. It houses musical organizations.

Maginnes Hall (1970). The multilevel structure is headquarters for the College of Arts and Science and also houses the departments of English, history, government, international relations, classics, and religion studies, as well as the Science, Technology, and Society Program,the Lehigh Valley Center for Jewish Studies, and the Center for International Studies. The university bookstore is located on the ground floor. The building is named for Albert B. Maginnes, '21, who was a lawyer and university trustee.

Mart Science and Engineering Library (1968). This structure honors the memory of Leon T. Mart, '13, and his son, Thomas, '51. It operates in conjunction with the E. W. Fairchild-Martindale Library and Computing Center.

Seeley G. Mudd Building (1975). This seven-story tower houses the chemistry department. The late Seeley G. Mudd was a California medical doctor. The Seeley G. Mudd Foundation, of Los Angeles, made a major gift toward the building.

Neville Hall (1975). This building in the chemistry complex has three auditoriums used for lectures and events. The building is named for Dr. Harvey A. Neville, president from 1961 to 1964, who was a chemist.

Newman Association Center. This Victorian structure, until the mid-1970s used as a private residence, was acquired by the Newman Association and serves as a center for students and as a residence for its director, a Roman Catholic chaplain.

Packard Laboratory (1929). The structure was the gift of James Ward Packard, Class of 1884, the electrical pioneer and inventor of the Packard automobile who served as a university trustee. The first Packard automobile (1898) is displayed in the lobby. The building is the headquarters for the College of Engineering and Applied Science. It also houses classrooms and laboratories for various departments. An auditorium accommodates large classes and various events.

Philosophy Building (1879). This small building just below Packer Memorial Church was constructed as a porter's lodge. Today it houses the philosophy department.

Price Hall. This structure formerly was a brewery named Die Alte Brauerei. In 1912 it was remodeled to serve as a dormitory, and it was named in honor of Henry Reese Price, president of the university board of trustees. It serves as the home of the social relations department.

Rathbone Hall (1971). This building's upper level is a major student dining facility, with window walls affording a panoramic view of the Lehigh Valley. The building bears the name of its donor, Monroe Jackson Rathbone, '21, president of the university board of trustees from 1957 to 1973. Rathbone was chairman of the board, Standard Oil Co. (New Jersey), now Exxon Corp., and was a major innovator in the oil industry. The lower level houses the residence operations office.

Sayre Building (1869). Originally known as the Sayre Observatory, the facility in 1985 became the quarters of the Computer Store.

Sherman Fairchild Center for the Physical Sciences (1892, 1976, 1986). The center houses classrooms and laboratories for undergraduate and graduate students in physics, and also contains a new 260-seat auditorium. It consists of the original five-story stone structure built in 1892, the Sherman Fairchild Laboratory for Solid-State Studies built in 1976, and an addition built in 1985 with help from the Sherman Fairchild Foundation.

Sinclair Laboratory (1970). This facility houses the Center for Surface and Coatings Research, and other research laboratories. It is named for Francis MacDonald Sinclair, and was the gift of his widow, Jennie H. Sinclair.

Whitaker Laboratory (1965). This five-story structure with an adjoining two-level classroom-auditorium section honors the memory of Martin Dewey Whitaker, university president from 1946 to 1960. The buildings serve the departments of materials science and engineering and chemical engineering. There are laboratories for high-pressure research and reaction kinetics, nuclear studies, analog computation, process control, high-temperature thermodynamics and kinetics, and fine structures and metallography. The Graduate School office and the office of the vice president for research are located in the building.

Williams Hall (1903). This brick structure was the gift of Edward H. Williams, Jr., Class of 1875. Dr. Williams was a professor of mining and geology. The building contains classrooms and laboratories for the departments of biology and of geological sciences. A small greenhouse adjoins the building. The building was extensively renovated and a fourth story added in 1956 following a fire.

Athletic and Convocational Facilities

Grace Hall (1940). The building is named for its donor, Eugene G. Grace, Class of 1899, who was chairman of Bethlehem Steel Corp. and president of the university's board of trustees, 1924 to 1956. The building's lower level seats 3,200 and is used for intramural sports, basketball, wrestling, and women's varsity volleyball as well as concerts and lectures. The upper level accommodates the military science and aerospace studies departments.

Philip Rauch Field House (1976). Philip Rauch, '33, made a gift toward the facility. The building has 62,000 square feet of uninterrupted floor space—the equivalent of two football fields—for a variety of athletic activities. It has a six-lane, one-eighth-mile flat track.

Sayre Field (1961). Located atop South Mountain, the field is used for softball and other sports.

Stabler Athletic and Convocation Center (1979). This arena provides seating for 6,000 persons for concerts, spectator sports, and other events. University trustee Donald B. Stabler, '30, made a major financial contribution toward the facility.

Taylor Gymnasium (1913 and 1904). This structure was the gift of Charles L. Taylor, Class of 1876, who was a friend and business associate of steel magnate Andrew Carnegie. There are two indoor swimming pools, five basketball courts, and two weight rooms. The department of intercollegiate athletics is housed here.

Taylor Stadium (1916). The stadium seats 17,000 persons. It is located on the eastern end of the main campus, on the site of athletic grounds that were opened in 1880. The facility is named for Charles L. Taylor, Class of 1876, who served as university trustee from 1882 to 1922. By 1988, it is expected that the stadium will be razed, superseded by a new facility on the Saucon Valley Campus. A headquarters building for business and economics would be constructed on the site.

Varsity House (1963). The building houses lockers for varsity teams. It is located on the Murray H. Goodman Campus.

Wilbur Drama Workshop (1908). During most of its life, the building served as a power plant. Renovated during the 1970s, it provides performing space for student theatrical productions.

Power Facility

Central Heating and Refrigeration (1969). This glass-walled building houses three boilers that can be fired by either oil or gas. Other equipment provides chilled water for air conditioning.

Technology Center

Ben Franklin Building (1972). Situated on the Murray H. Goodman Campus in Saucon Valley, the building houses the Lehigh-based North East Tier Ben Franklin Advanced Technology Center.

Residential Facilities

The university is primarily residential in character, with more than 85 percent of undergraduates living in facilities on the campus, including university-operated residence halls and independently managed fraternity and sorority houses.

More than 2,000 students live in on-campus residence halls and similar facilities.

Residence Halls

Brodhead House (1979). This structure, the university's first high-rise residential facility, houses 200 students. The six-story building includes student suites on the five upper floors, with a dining facility and lobby on the entrance level. The building is named in memory of Albert Brodhead, a member of the Class of 1888 who died in 1933, leaving 51 Bethlehem properties to his alma mater.

Centennial I complex (1965)

Congdon House. Dr. Wray H. Congdon served as dean of students, dean of the Graduate School, and special assistant to the president. Alpha Phi sorority is housed in Congdon.

Emery House. It is named for Dr. Natt M. Emery, who was vice president and controller. Gamma Phi Beta sorority is housed in Emery.

Leavitt House. The Rev. Dr. John McD. Leavitt was the second president, 1875 to 1879. Alpha Gamma Delta sorority is housed in Leavitt.

McConn House. C. Maxwell McConn was dean of the university from 1923 to 1938. Alpha Omicron Pi sorority is housed in McConn.

Smiley House. Dr. E. Kenneth Smiley served as vice president from 1945 to 1964. Kappa Alpha Theta sorority is housed in Smiley.

Thornburg House. Dr. Charles G. Thornburg was professor and head of the department of mathematics, 1895 to 1923. His grandson, Dick Thornburgh, completed his second term as governor of Pennsylvania at the end of 1986. Delta Gamma sorority will occupy Thornburg in 1987.

Centennial II complex (1970)

Beardslee House. Dr. Claude G. Beardslee was chaplain from 1931 to 1947.

Carothers House. Dr. Neil Carothers was dean of business.

Palmer House. Dr. Philip M. Palmer was dean of the arts.

Stevens House. The Rt. Rev. William Bacon Stevens, of Philadelphia, was Protestant Episcopal bishop of the Diocese of Pennsylvania and first president of the university board of trustees. He was the principal architect of the university's original academic plan.

Stoughton House. Dr. Bradley Stoughton was dean of the engineering college, 1936 to 1939.

Williams House. Dr. Clement G. Williams was president of the university, 1935 to 1944.

Other Houses

Dravo House (1948). This stone edifice is the university's largest residential facility. It bears the name of two brothers, Ralph M. Dravo, Class of 1889, and Francis F. Dravo, Class of 1887, who founded the Dravo Corp., a Pittsburgh-based international construction company. Both men served as university trustees.

Drinker House (1940). This stone building honors the memory of Henry S. Drinker, Class of 1871, university president from 1905 to 1920.

McClintic-Marshall House (1957). This U-shaped stone structure was built in memory of Howard H. McClintic and Charles D. Marshall, both Class of 1888, who founded the McClintic-Marshall Construction Co. The firm was the world's largest independent steel fabricating firm before its acquisition by Bethlehem Steel Corp. in 1931. It built locks for the Panama Canal and constructed the Golden Gate Bridge in San Francisco Bay.

Packer House. In 1985, this former fraternity house was changed to use as a university residence hall. The building is located on Packer Ave., just west of the main campus.

Richards House (1938). The building honors the memory of Charles Russ Richards, president of the university from 1922 to 1935. The building is constructed of stone in modified Gothic design.

Taylor Residential College (1907, 1984). The U-shaped building is one of the earliest concrete structures ever built. It was the gift of industrialist Andrew Carnegie in honor of his friend and associate, university trustee Charles L. Taylor, Class of 1876. The interior of the building was reconstructed and the exterior refinished prior to the facility becoming Lehigh's first residential college in 1984.

Trembley Park (1975). This seven-building undergraduate apartment complex is named in memory of Francis J. Trembley, Lehigh professor and pioneer ecologist.

Saucon Village Apartments (1974)

The five-building garden apartment complex includes housing for married and graduate students, and for undergraduates in Hartman, Gipson and More residential colleges.

Diamond. Dr. Herbert M. Diamond, professor emeritus of economics, retired in 1964.

Gipson. Dr. Lawrence Henry Gipson, research professor of history, bequeathed his estate to the university to establish the Lawrence Henry Gipson Institute for Eighteenth-Century Studies. Dr. Gipson wrote a monumental 15-volume history, *The British Empire Before the American Revolution*. He won the Pulitzer Prize for volume 10, *The Triumphant Empire: Thunderclouds Gather in the West, 1763-1766.*

Hartman Residential College. Dr. James R. Hartman was chairman of the department of mechanical engineering and mechanics. In 1985 the structure became Lehigh's second residential college.

More. Dr. Robert P. More, '10, dean of the College of Arts and Science, who also taught German for forty years, bequeathed to the university his $746,000 estate, amassed after investing $3,000 in IBM stock.

Severs. Dr. J. Burke Severs, of Bethlehem, is distinguished professor emeritus of English. He is a Chaucerian scholar.

Fraternities and Sororities

The university has a strong fraternity tradition, dating back to 1872. Since the admission of undergraduate women in 1971, several sororities have come into being. Some 1,200 men live in fraternities.

Most of the fraternities have houses located in Sayre Park, while a few others are situated off campus. All are chapters of national fraternities.

An alphabetical listing follows. The date of the founding of the chapter is given in the first column. A second year in the first column indicates reestablishment. The second column lists the date the chapter occupied its present house; any additional date indicates the most recent addition or major renovation.

Alpha Chi Rho	1918	1968
Alpha Epsilon Pi	1979	1978
Alpha Sigma Phi	1929	1961
Alpha Tau Omega	1886	1966
Beta Theta Pi	1891	1968
Chi Phi	1872	1922, 1968
Chi Psi	1893	1916, 1955
Delta Chi	1952	1968
Delta Phi	1884	1963
Delta Tau Delta	1874, 1985	1959
Delta Upsilon	1885	1968
Kappa Alpha	1894	1961
Kappa Sigma	1900	1973
Lambda Chi Alpha	1926	1973
Phi Delta Theta	1876	1919, 1963
Phi Sigma Kappa	1901	1957, 1970
Pi Kappa Alpha	1929	1903
Pi Lambda Phi	1915	1965
Psi Upsilon	1884	1909, 1966
Sigma Alpha Mu	1923	1966
Sigma Chi	1887	1953
Sigma Nu	1885	1970
Sigma Phi	1887	1950, 1961
Sigma Phi Epsilon	1907	1963
Tau Epsilon Phi	1963	1964
Theta Chi	1942	1964
Theta Delta Chi	1884	1937, 1967
Theta Xi	1904	1967
Zeta Psi	1973	1973

There are six sororities. All are nationally affiliated.

The sororities are listed with year of establishment at Lehigh in the first column, year of moving into present residence in the second column, and year of moving into the Centennial complex in the third column. Some 250 women reside in sorority houses.

Alpha Gamma Delta	1975	1981	1985
Alpha Phi	1975	1981	1984
Gamma Phi Beta	1975	1981	1985
Delta Gamma	1982	1982	1987
Alpha Omicron Pi	1983	1984	1986
Kappa Alpha Theta	1984	1984	1986

In Bethlehem, An Educational Tradition

Lehigh University shares in the historical heritage of Bethlehem, even though, having been founded in 1865, it is a relative newcomer. The fact that Lehigh was established in Bethlehem reflects the tradition of education established by the community's first settlers thirty years before the founding of the nation.

The first Moravians were among the many German religious sects that came to the New World, and especially to Pennsylvania, during the early 1700s. But unlike William Penn, who established his *sylvania* as a new land where he might hold his Quaker beliefs away from England's oppression, the Moravians came as missionaries with the intent of converting the Indians to Christianity. For this purpose they settled the Lehigh Valley.

The early Moravians were industrious. Their first building, the Gemein Haus (community house) was completed in 1741. This building stands today, one of thirty-nine remarkably preserved pre-Revolutionary War buildings constructed by the Moravian settlers and in continuous use ever since by the Moravian community. Many of these buildings are located on Church St., west of the City Center; industrial buildings are located in the 18th Century Industrial Area in the Monocacy Creek valley west of the business district.

The leader of the Moravians was Count Nicholas von Zinzendorf of Dresden. He arrived in the settlement in time for their observance of Christmas Eve in 1741 and gave the settlement the name Bethlehem—"house of bread".

The settlers built high-quality structures of stone, demonstrating principles of engineering that were not generally used elsewhere. They were interested in music, and established the first symphony orchestra in America. In 1748, the settlement had a fourteen-man orchestra. The community's first organ was built in 1757 by John Gottlob Klemm. The musical tradition, including the trombone choir, continues today, perhaps most visibly in the Bach Choir of Bethlehem, whose yearly Bach Festival is held in the university's Packer Memorial Church. In 1985, the 300th anniversary of the birth of Johann Sebastian Bach was observed.

Zinzendorf envisioned Bethlehem as the center for manufacturing; outlying Moravian settlements, such as Nazareth, Pa., would be primarily devoted to agriculture. On October 15, 1742, a large barn was "raised" with the help of most of the residents. Three months later a grist mill at the community spring produced the first flour. In 1758, the Sun Inn was built along Main St., a haven for travelers. Reconstruction of the picturesque inn was completed in 1982, and it now operates as a community center and public dining facility.

Zinzendorf's determination that Bethlehem would be a major industrial center was assisted by the completion in 1755 of the water works, the first public utility in the New World.

The Moravian dedication to education was an extension of the philosophy of Amos Comenius, who had written, "Everyone ought to receive a universal education." The Moravian educational institutions that continue today, including Moravian College, stem from this tradition.

The Moravians, although avowedly opposed to war, found their community pressed into service as a hospital when Washington's troops bivouacked at Valley Forge during the winter of 1777-78. Washington came to the community once,

and many other Continental Army officers were visitors.

The Sun Inn was also used as a hospital during the war; among its patients was an aristocratic renegade from France, Marie Joseph Paul Ives Gilbert Motier, the Marquis de la Fayette. Lafayette had come to assist the Continental Army aboard his own ship, the "Victory." Fifty years later a college in Easton was named in his honor and it became Lehigh's traditional football rival.

The first bridge across the Lehigh River was built in 1794. It was replaced in 1816, but the latter was destroyed by a flood in 1841. In 1759, the turnpike (toll road) over South Mountain, generally along the route of the present Wyandotte St. hill, was opened. The present Hill-to-Hill Bridge was built some fifty years ago.

"Black gold." During the late 18th Century, anthracite was found in the mountains north of the Lehigh Valley. In 1818, the Lehigh Coal Co. and the Lehigh Navigation Co. were formed, one to mine the anthracite on the upper Lehigh River, the other to transport it downriver to metropolitan markets.

The Lehigh River was difficult to navigate. Consequently, in 1829 the Lehigh Canal was completed from Mauch Chunk (now Jim Thorpe), through Bethlehem to Easton, where it connected with the Delaware Canal. During the 1840s, iron mines were opened in the area, and several blast furnaces, fueled by coal, were in operation. Zinc ore, was found in neighboring Upper Saucon Township. In the 1850s Asa Packer built the Lehigh Valley Railroad. These origins eventually led to the heavy industry that continues in the Lehigh Valley today.

When Asa Packer founded Lehigh University in 1865, one of his objectives was to make possible broadly based education for young people of the region, combining the technical skills needed to run the flourishing industry of the Lehigh Valley with a liberal education.

In addition to its role as a steel-making center, Bethlehem today is a major tourist attraction. The Moravian community sets up an elaborate nativity scene and the entire city is decorated with lighting during the holiday period. The Moravian tradition of a single candle (now electric) in each window is widely observed.

Atop South Mountain is a steel tower known as the Star of Bethlehem. During the holiday period, the star's hundreds of bulbs create a 95-foot-high star that can be seen for many miles. The star was the gift to the community of Marion Brown Grace, wife of Eugene Gifford Grace, the steel magnate and president of the university board of trustees.

The community of Bethlehem has a population of approximately 78,000 persons with segments from a variety of nations who retain traditions of their country of origin.

Bethlehem's principal employer is Bethlehem Steel Corp. The corporation maintains a manufacturing facility and corporate headquarters in Bethlehem. A number of high-technology firms also operate in the Lehigh Valley, most notably Air Products and Chemicals, Inc., and AT&T Technologies.

There are five principal independent colleges in the Lehigh Valley besides Lehigh. They are Lafayette, Allentown College of St. Francis de Sales, Moravian, Muhlenberg, and Cedar Crest. A cooperative program is maintained that allows cross-registration for courses as well as shared cultural events. There are also two community colleges in the area.

In 1984, Bethlehem held its first Musikfest, combining Germanic music and food. An instant success, Musikfest was the brainchild of Jeffrey A. Parks, a lawyer and 1970 Lehigh graduate. Parks is president of the Bethlehem Musikfest Association, which continues to sponsor the ten-day festival every August.

"Lehigh Canal—Below Niski, 1905." A boat plies the Lehigh Canal, almost a century after the canal was built by Asa Packer, who founded the university in 1865.

VII.

Administration, Faculty, and Staff

This section lists the people whose talents and abilities constitute the university's most important resource. Members of the board of trustees contribute their expertise to establish the policies of the university. Also listed are the administration, members of the faculty and staff, and the members of the visiting committees who help to keep courses of instruction current and of maximum value to the students and prospective employers.

Board of Trustees

When the year of the degree is listed, the degree was awarded by Lehigh University.

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Edward G. Uhl, chairman
John W. Woltjen, secretary and treasurer
Elmer W. Glick, honorary secretary

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Joseph R. Perella, B.S. '64, M.B.A., New York City, managing director, First Boston Corp., New York.

Frank C. Rabold, B.S. '39, Eng.D. '70, Saylorsburg, Pa., retired manager of corporate services, Bethlehem Steel Corp.

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The Rt. Rev. Dean T. Stevenson, B.A., '37, S.T.B., M.A. '49, D.D., Harrisburg, Pa., retired bishop of the Episcopal Diocese of Central Pennsylvania.

James B. Swenson, B.B.A. '59, Wellesley, Mass., partner, Price Waterhouse.

Edward G. Uhl, B.S., '40, Sc.D. '74, Trappe, Md., retired corporate chairman of the board, Fairchild Industries.

Joseph M. Workman, B.S. '53, B.S. '54, Bethlehem, Pa., manager of business planning, Bethlehem Steel Corp.

Honorary Trustees

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Committees of the Board

Executive committee. Mr. Uhl, chairman; the Messrs. Hittinger, Mohler, Pendleton, Rabold, Smith, and Stabler, members.

Academic affairs committee. Mr. Hittinger, chairman; Mr. Stabler, vice chairman; the Messrs. Peter G. Beidler, Cullen, Diamond, Fleckenstein, Hoffman, Mercy, Swenson, and Bishop Stevenson, members

Audit committee. Mr. Holmes, chairman; Mr. Smith, vice chairman; the Messers. John B. O'Hara and Peller, members.

Development committee. Mr. Stabler, chairman; the Messrs. Clayton, Andrew J. Conway, Diamond, Eagleson, Richard H. Francis, Goodman, Mercy, Mohler, and Perella, members.

Finance committee. Mr. Smith, chairman; Mr. Eagleson, vice chairman; the Messrs. Clayton, Francis, Holmes, James N. Land, Jr., Pendleton, Perella, and William D. Washychyn, members.

Investment subcommittee. Mr. Pendleton, chairman; the Messrs. Clayton, Francis, Land, Perella, and Washychyn, members.

Nominating committee. Mr. Uhl, chairman; the Messrs. Donald H. Bott, Paul J. Franz, Jr., Hittinger, Mohler, and Pendleton, members.

Physical planning and plant committee. Mr. Rabold, chairman; Mr. Richman, vice chairman; the Messrs. Berg, Bridgman, Goodman, Riemondy, and Gregory D. Schulze, members.

Research committee. Mr. Fleckenstein, chairman; the Messrs. Cullen, Diamond, and Hoffman, members.

Student affairs committee. Mr. Mohler, chairman; Mr. Scheetz, vice chairman; the Misses Karen A. Thompson and Marson; the Messrs. Peter J. Fioretti, Grannatt, Jr., Peller, and Workman, members.

Visiting Committees

A university both serves and advances society. It accomplishes this through various highly specialized academic, research, and service divisions. To achieve a perspective of societal needs and goals and the direction and role to be played by the university, the university and society must develop links of communication. At Lehigh University, one means of forging such links is through involvement of specialists outside the university with university personnel.

In addition, it is essential to the progress of the university that the direction and quality of each unit be maintained. The regular visit of a group of highly qualified individuals from the outside provides both a stimulus for self-appraisal by a given department or division, and an objective view by an outside group of the work of that unit.

Therefore, to forge these communication links and to maintain continuous interaction of the units of the university with the off-campus world, the Lehigh board of trustees on June 4, 1965, established visiting committees. A listing of committees follows.

Art and Architecture

S. Murray Rust, Jr., *chairperson*, Orleans, Mass., retired chairman, Rust Engineering Co.

John Coolidge, Cambridge, Mass., professor of fine arts, Fogg Museum, Harvard University

Dorothy Gillespie, New York City, director, Art in the Community Institute, New School for Social Research

Murray H. Goodman, Palm Beach, Fla., chairman of the board, The Goodman Company

Andrew MacNair, Brooklyn, N.Y., chairperson of undergraduate architecture, Pratt Institute.

Intercollegiate Athletics

C. Keith Rust, *chairperson*, Bethlehem, Pa., president, Roland and Roland, Inc.

Curtis F. Bayer, honorary member, Chagrin Falls, Ohio, retired vice president, Erie Lackawanna Railroad

Lee A. Butz, Allentown, Pa., president, Alvin H. Butz, Inc., general contractors

Edward N. Cahn, Allentown, Pa., U.S. district judge

Samuel W. Croll, Jr., Orleans, Mass., and Naples, Fla., retired president, Croll-Reynolds Co., Inc.

Samuel C. Howell, Princeton, N.J., associate director of athletics, Princeton University

Nancy Barrett Kreider, Cincinnati, Ohio, alumni representative

Joseph M. Workman, Bethlehem, Pa., manager of business planning, Bethlehem Steel Corp.

Biology

Harold S. Mohler, *chairperson*, Hershey, Pa., retired chairman of the board, Hershey Foods Corp.

Bert DelVillano, Malvern, Pa., vice president of marketing and sales, Centocor

Douglass H. Morse, Providence, R.I., Hermon Carey Bumpus Professor of Biology, Brown University

Stephanie Olexa, Allentown, Pa., section manager, research and development, Air Products and Chemicals, Inc.

Nalin Unakar, Rochester, N.Y., chairman, department of biology, Oakland University

Jerome J. Wolken, Pittsburgh, Pa., professor emeritus of biophysics, Carnegie-Mellon University

College of Business and Economics

Eugene Mercy, Jr., *chairperson*, New York City, partner, Goldman Sachs & Co.

Robert B. Gill, New York City, vice chairman, J.C. Penney Co., Inc.

William L. Gladstone, New York City, chairman and chief executive officer, Arthur Young & Co.

Murray H. Goodman, Palm Beach, Fla., chairman of the board, The Goodman Company.

James N. Land, Jr., Short Hills, N.J., financial consultant

Joseph R. Perella, New York City, managing director, The First Boston Corp.

Lunsford Richardson, Jr., Norwalk, Conn., retired director, Richardson-Vicks

Paul J. Uselding, Champaign, Ill., professor of economics, University of Illinois

Robert L. Virgil, St. Louis, Mo., dean and professor of accounting, Graduate School of Business Administration and School of Business and Public Administration, Washington University

Chemical Engineering

Harold S. Mohler, *chairperson*, Hershey, Pa., retired chairman of the board, Hershey Foods Corp.

W. James Porter, Jr., Darien, Conn., vice president, chemical technology department, Exxon Chemical Co.

Charles J. Prizer, Philadelphia, Pa., group vice president, corporate operations, Rohm and Haas Corp.

William R. Schowalter, Princeton, N.J., chairman and professor of chemical engineering, Princeton University

Kenneth A. Smith, Cambridge, Mass., associate provost and professor of chemical engineering, Massachusetts Institute of Technology

Paul V. Tebo, Wilmington, Del., technical director of research and development division, Polymer Products Department, E.I. du Pont de Nemours & Co.

Chemistry

John D. Cullen, *chairperson*, Wilmington, Del., vice president and chief engineer, E.I. du Pont de Nemours & Co.

Irving D. Isko, Morristown, N.J., retired chief executive officer, Engelhard Corp.

James F. Roth, Allentown, Pa., director, Corporate Science Center, Air Products and Chemicals, Inc.

Morton K. Schwartz, New York City, chairman and professor of clinical chemistry, Memorial Sloan Kettering Cancer Center

Civil Engineering and Fritz Engineering Laboratory

Donald B. Stabler, *chairperson*, Harrisburg, Pa., president and chairman of the board, Stabler Companies, Inc.

John F. Kennedy, Iowa City, Iowa, Carver Distinguished Professor of Engineering and director, Institute of Hydraulic Research, The State University of Iowa

Robert L. Smith, Lexington, Mass., president, Robert L. Smith and Associates

Classics

The Rt. Rev. Dean T. Stevenson, *chairperson*, Lemoyne, Pa., retired bishop, Episcopal Diocese of Central Pennsylvania

Eleanor Leach, Bloomington, Ind., professor of classical studies, Indiana University

William C. Scott, Hanover, N.H., professor of classics, Dartmouth College

Alan Watson, Philadelphia, Pa., professor of law, University of Pennsylvania

Computer Science and Electrical Engineering

William O. Fleckenstein, *chairperson*, Colts Neck, N.J., retired vice president, Bell Communications Research

David F. Barbe, College Park, Md., associate director, Engineering Research Center, University of Maryland

Thomas H. Crowley, Madison, N.J., retired vice president for software systems, AT&T Technology Systems

Paul C. Ely, Jr., San Jose, Calif., president and chief executive officer, Convergent Technologies, Inc.

George I. Haddad, Ann Arbor, Mich., chairman and professor of electrical engineering, University of Michigan

Charles P. Meetsma, Allentown, Pa., vice president for manufacturing, AT&T Technology Systems

Lotfi A. Zadeh, Berkeley, Calif., professor of electrical engineering and computer science, University of California at Berkeley

Computing Center

Thomas H. Crowley, *chairperson*, Madison, N.J., retired software systems vice president, AT&T Technology Systems

Bruce Gilchrist, New York City, director, computing activities, Columbia University

Edward E. Shaw, Stanford, Calif., director, information technology services, Stanford University

College of Education

Joseph M. Workman, *chairperson*, Bethlehem, Pa., manager, business planning, Bethlehem Steel Corp.

Sylvia Charp, Upper Darby, Pa., editor-in-chief, TECHNOLOGICAL HORIZONS IN EDUCATION

Edwin L. Herr, University Park, Pa., head and professor of counseling and educational psychology, Pennsylvania State University

Caryl M. Kline, Pittsburgh, Pa., retired secretary of education, Pennsylvania State Department of Education; educational consultant

Frank S. Manchester, Harrisburg, Pa., executive director, Pennsylvania Association of Elementary and Secondary School Principals

Energy Research Center

Heinz G. Pfeiffer, *chairperson*, Allentown, Pa., manager, technology and energy assessment, Pennsylvania Power and Light Co.

Peter L. Auer, Ithaca, N.Y., professor of mechanical and aerospace engineering, Cornell University

John Bachofer, Reading, Pa., vice president, Generation, Metropolitan Edison Co.

David M. Eissenberg, Oak Ridge, Tenn., program manager, Engineering Technology Division, Oak Ridge National Laboratory

Thomas E. Stelson, Atlanta, Ga., vice president of research, Georgia Institute of Technology

English

William L. Clayton, *chairperson*, New York City, executive vice president and director, E.F. Hutton & Co.

Donna Gerstenberger, Seattle, Wash., professor of English, University of Washington

John Kuehl, New York City, professor of English, New York University

Donald Ross, Jr., Minneapolis, Minn., professor of English, University of Minnesota

Victoria Weiss, Atlanta, Ga., associate professor of English, Oglethorpe University

Geological Sciences

Philip J. Berg, *chairperson*, Sewickley, Pa., retired executive vice president, Dravo Corp.

Shelton S. Alexander, University Park, Pa., chairman and professor of geophysics, Pennsylvania State University

Stephen P. Morzenti, Glenrock, Wyo., project manager, Everest Mineral Corp.

John T. Palmer, Shreveport, La., president, Palmer Petroleum, Inc.

George W. Roland, Latrobe, Pa., vice president and director of technology, Kennametal, Inc.

Leon T. Silver, Pasadena, Calif., professor of geology, California Institute of Technology

Robert I. Tilling, Reston, Va., geologist, Branch of Igneous and Geothermal Processes, U.S. Geological Survey

Government

Philip R. Peller, *chairperson*, Glen Head, N.Y., partner, Arthur Andersen & Co.

Lon S. Babby, Washington, D.C., Williams and Connolly

Edward P. Flood, Philadelphia, Pa., Criminal Prosecuting Administration, district attorney's office

Trond Gilberg, University Park, Pa., professor and chairperson, department of political science, Pennsylvania State University

Marion R. Just, Wellesley, Mass., chairperson and professor of political science, Wellesley College

Robert LaPorte, Jr., University Park, Pa., professor of public administration and director, Institute of Public Administration, Pennsylvania State University

History

Frank C. Rabold, *chairperson*, Pocono Summit, Pa., retired general manager of corporate services, Bethlehem Steel Corp.; president, Unidel Corp.

Charles D. Ameringer, University Park, Pa., professor of history, Pennsylvania State University

Philip Cash, Boston, Mass., chairman and professor of history, Emmanuel College

Daniel S. Hirshfield, Farmington Hills, Mich., director of communication services, Chrysler Motors Corp.

Alice Kessler-Harris, Hempstead, N.Y., professor of history, Hofstra University

Dominick A. Lockwood, Easton, Pa., attorney-at-law

Orest Ranum, Baltimore, Md., professor of history, Johns Hopkins University

Merrit Roe Smith, Cambridge, Mass., professor of history, Massachusetts Institute of Technology

Industrial Engineering

Everett H. Van Hoesen, *chairperson*, Milford, Conn., retired president, Industrial Systems Division, IBM Corp.

L. Jack Bradt, Easton, Pa., chairman, The Systems Innovators Handling Systems, Inc.

Michael M. Danchak, Hartford, Conn., dean, School of Engineering and Science, The Hartford Graduate Center

Thomas L. Kelly, Jr., Shelton, Conn., chief executive officer, TIE/Communications, Inc.

Patterson H. Krisher, New York City, national director of management services and partner, Arthur Young & Co.

George T. Rehfeldt, Cincinnati, Ohio, group vice president, Industrial Specialty Products, Cincinnati Milacron, Inc.

John A. White, Atlanta, Ga., professor of industrial engineering and director, Material Handling Research Center, Georgia Institute of Technology

International Relations

James M. Bridgman, *chairperson*, New Canaan, Conn., retired program manager, employee relations for Far East, IBM World Trade/Far East; consultant, IBM Corp.

Samuel Efron, Washington, D.C., senior partner, Arent, Fox, Kintner, Plotkin & Kahn

William C. Hittinger, Princeton, N.J., retired executive vice president, research and engineering, RCA Corp.

Roger E. Kanet, Urbana, Ill., professor and head, department of political science, University of Illinois at Urbana-Champaign

Gerard J. Mangone, Newark, Del., H. Rodney Sharp Professor of International Law and Organization and director, Center for the Study of Marine Policy, University of Delaware

Donald J. Puchala, Columbia, S.C., professor of international relations and director, Center for International Studies, University of South Carolina

Kenneth W. Thompson, Charlottesville, Va., Commonwealth Professor of Government and Foreign Affairs, White Burkett Miller Center of Public Affairs, University of Virginia

Journalism

Kirk P. Pendleton, *chairperson*, Huntingdon Valley, Pa., president, Cairnwood, Inc.

Eileen Canzian, Baltimore, Md., reporter, BALTIMORE SUN

James F. Dulicai, New York City, manager of creative services, Mobil Oil Corp.

Kenneth Goldstein, New York City, professor, School of Journalism, Columbia University

Robert Teufel, Jr., Emmaus, Pa., president, Rodale Press, Inc.

Robert M. Walters, Washington, D.C., syndicated columnist

University Libraries

William B. Eagleson, Jr., *chairperson*, Malvern, Pa., retired chairman of the board, Mellon Bank (East) and Mellon Bank Corp.

Patricia Battin, New York City, vice president and university librarian, Columbia University

Guy Garrison, Philadelphia, Pa., dean, College of Information Studies, Drexel University

David Stam, Syracuse, N.Y., university librarian, Syracuse University

William J. Welsh, Washington, D.C., deputy librarian of Congress, Library of Congress

Center for Marine and Environmental Studies

Thomas E. Hirsch III, *chairperson*, New York City, appellate attorney, Chadburne, Parke, Whiteside, and Wolfe

Robert B. Abel, Fort Hancock, N.J., president, New Jersey Marine Sciences Consortium

Anthony F. Gaudy, Jr., Newark, Del., H. Rodney Sharp Professor of Civil Engineering, University of Delaware

Alonzo W. Lawrence, Pittsburgh, Pa., vice president for science and technology, Koppers Co. Inc.

Department of Materials Science and Engineering, and Materials Research Center

Frederick C. Langenberg, *chairperson*, Oak Brook, Ill., chairman and chief executive officer, Interlake

Joseph E. Burke, Burnt Hills, N.Y., retired manager of special projects, General Electric Research and Development Center

Ralph C. Leinbach, Jr., Reading, Pa., senior vice president, technology, engineering, and purchasing, Carpenter Steel Division, Carpenter Technology Corp.

William R. Prindle, Corning, N.Y., director of administrative and technical services, Research and Development Division, Corning Glass Works

Darrell H. Reneker, Gaithersburg, Md., deputy director, Polymers Division, U.S. Department of Commerce, National Bureau of Standards

Department of Mathematics

William C. Hittinger, *chairperson*, Princeton, N.J., retired executive vice president, research and engineering, RCA Corp.

William Browder, Princeton, N.J., professor of mathematics, Princeton University

Julian Cole, Troy, N.Y., professor of mathematics, Rensselaer Polytechnic Institute

Andrew M. Gleason, Cambridge, Mass., professor of mathematics, Harvard University

Ronald L. Graham, Murray Hill, N.J., director, Mathematical Sciences Research Center, Bell Laboratories

Juris Hartmanis, Ithaca, N.Y., professor of computer science, Cornell University

John W. Tukey, Murray Hill, N.J., Donner Professor of Science, department of statistics, Princeton University, and associate executive director, Bell Laboratories

Mechanical Engineering and Mechanics

Robert H. Riley, Jr., *chairperson*, Towson, Md., retired director of research, Black and Decker Manufacturing Co.

Donald P. Ames, St. Louis, Mo., staff vice president, McDonnell Douglas Research Laboratories

John Austin Brighton, Atlanta, Ga., head, School of Mechanical Engineering, George Institute of Technology

Bernard Budiansky, Cambridge, Mass., Gordon McKay Professor of Mechanical Engineering, Harvard University

Richard E. Disbrow, Columbus, Ohio, president and chief administrative officer, American Electric Power Service Corp.

William M. Kays, Stanford, Calif., professor of mechanical engineering, Stanford University

Zdenek J. Lansky, Cleveland, Ohio, vice president, Parker Hannifin Corp.

David H. Mitchell, Norwalk, Conn., group director, supply management, Information Systems Group, IBM Corp.

Modern Foreign Languages and Literature

Edwin F. Scheetz, Jr., *chairperson*, Pittsburgh, Pa., chairman, Scheetz, Smith & Co., Inc.

Ernest A. Scatton, Albany N.Y., director, program in linguistics, State University of New York at Albany

Molecular Bioscience and Biotechnology Research Center

Theodore L. Diamond, *chairperson*, New York City, president, T.L. Diamond & Co., Inc.

Bert DelVillano, Malvern, Pa., vice president of marketing and sales, Centocor

Thomas M. Devlin, Philadelphia, Pa., professor and chairman, department of biological chemistry, Hahnemann University School of Medicine

Stephen W. Drew, Rahway, N.J., director, biochemical engineering, Merck & Co., Inc.

Renato Fuchs, Union, N.J., senior director, biotechnology research development, Schering Corp.

Richard K. Quisenberry, Wilmington, Del., director, biotechnology research division, E.I. du Pont de Nemours & Co., Inc.

Morton K. Schwartz, New York City, chairman and professor of clinical chemistry, Memorial Sloan-Kettering Cancer Center

Music

John Heiss, *chairperson*, Boston, Mass., professor of music, New England Conservatory of Music

Joseph Flummerfelt, Princeton, N.J., director of choral activities, Westminster Choir College

Mildred Parker, Philadelphia, Pa., professor of musicology, Temple University

Philosophy

Augustus A. Riemondy, *chairperson*, Hershey, Pa., retired brigadier general, U.S. Air Force; retired assistant to the president, Hershey Foods Corp.

Daniel C. Dennett, Medford, Mass., professor of philosophy, Tufts University

Gilbert Harman, Princeton, N.J., professor of philosophy, Princeton University

Hugh M. Lacey, Swarthmore, Pa., professor of philosophy, Swarthmore College

Dudley Shapere, Winston-Salem, N.C., professor of philosophy, Wake Forest University

Physics

Ronald R. Hoffman, *chairperson*, Pittsburgh, Pa., vice president, Flat-rolled Products Division, Aluminum Company of America

Robert A. Gross, New York City, Dean and Percy K. and Vida L.W. Hudson Professor of Applied Physics, Columbia University

Michael J. Thompson, Allentown, Pa., executive director, PA Labs, Integrated Circuit Processing Division, Bell Laboratories

Walter D. Wales, Philadelphia, Pa., professor of physics, University of Pennsylvania

Robert G. Wheeler, New Haven, Conn., professor of applied physics, Yale University

Rennos Zaphiropoulos, Santa Clara, Calif., president, Versatec, Inc.

Psychology

Augustus A. Riemondy, *chairperson*, Hershey, Pa., retired brigadier general, U.S. Air Force; retired assistant to the president, Hershey Foods Corp.

Joseph H. Grosslight, Tallahassee, Fla., professor and chairman, department of psychology, Florida State University

William Kessen, New Haven, Conn., Eugene Higgins Professor of Psychology and professor of pediatrics, Yale University

Marsha B. Marson, Charlestown, Mass., manufacturing specialist, The New Can Co., Inc.

Walter Mischel, New York City, professor of psychology, Columbia University

Eliot Stellar, Philadelphia, Pa., professor of anatomy, School of Medicine, University of Pennsylvania

Religion Studies

The Very Rev. Daniel Gambet, OSFS, *chairperson*, Center Valley, Pa., president, Allentown College of St. Francis de Sales

Kalman P. Bland, Durham, N.C., chairman and professor of religion, Duke University

Jill Raitt, Columbia, Mo., chairwoman and professor of religious studies, University of Missouri

Charles H. Reynolds, Knoxville, Tenn., chairperson and professor of religious studies, University of Tennessee

Robert L. Wilken, Charlottesville, Va., professor of religious studies, University of Virginia

Sherman Fairchild Center for Solid-State Studies

William O. Fleckenstein, *chairperson*, Colts Neck, N.J., retired vice president, Bell Communications Research

Lionel Kimerling, Murray Hill, N.J., head, materials physics research, AT&T Bell Laboratories

Denish Mehta, Allentown, Pa., director, Silicon Processing Technology Laboratory, AT&T Bell Laboratories

T. D. Ramachandran, Lowell, Mass., president, M/A-COM Advanced Semiconductor Operations

James J. Tietjen, Princeton, N.J., director, materials research, RCA Corp.

Social Relations

Stanley M. Richman, *chairperson*, Millburn, N.J., vice president, Lightning Electric Co.

John M. Darley, Princeton, N.J., professor of psychology, Princeton University

A. Thomas Kirsch, Ithaca, N.Y., professor of anthropology, Cornell University

Center for Social Research

Milton H. Grannatt, Jr., *chairperson*, West Trenton, N.J., chairman, Fell and Moon Co.

Henry McIlvaine Parsons, Alexandria, Va., consultant, Essex Corp.

Stewart Wolf, M.D., Bangor, Pa., director, Totts Gap Medical Laboratory

Division of Speech and Theater

Janet M. Ryan, *chairperson*, Mountain View, Calif., regional sales manager, Personal Computing, Hayden Publishing Co., Inc.

Lucille Bunin Askin, honorary member, Scarsdale, N.Y., art lecturer

Arthur W. Bloom, San Antonio, Texas, professor and chairman, department of speech and theatre, Trinity University

George C. Izenour, Stony Creek, Conn., professor emeritus of theater and technology

Student Life

Milton H. Grannatt, Jr., *chairperson*, Trenton, N.J., chairman, Fell and Moon Co.

Ernest Ern, Charlottesville, Va., vice president for student affairs, University of Virginia

Thomas E. Hirsch III, New York City, appellate attorney, Chadburne, Parke, Whiteside, and Wolfe

Stanley M. Richman, Millburn, N.J., vice president, Lightning Electric Co.

Janet M. Ryan, Mountain View, Calif., regional sales manager, Personal Computing, Hayden Publishing Co., Inc.

Arthur Sandeen, Gainesville, Fla., vice president for student affairs and professor of educational administration, University of Florida

Center for Surface and Coatings Research

Brian Rushton, *chairperson*, Allentown, Pa., vice president, research and development, Air Products and Chemicals, Inc.

Michel Boudart, Stanford,Calif., William J. Keck Professor of chemical engineering, Stanford University

Donald P. Seraphim, Endicott, N.Y., materials engineering manager, IBM Corp.

Members of the Administration

Educational information (degrees earned and colleges and universities attended) may be found in the alphabetical listing that follows in this secton. The highest degree earned is given.

All offices, unless otherwise noted, are located at Bethlehem, Pa. 18015; the area code, unless otherwise noted, is (215).

Offices of the President and Provost

Alumni Memorial Building 27; 758-3155

Peter Likins, Ph.D., president
David A. Sanchez, Ph.D., provost and vice president
Marsha A. Duncan, M.S., vice president for student affairs
Paul J. Franz, Jr., M.A., vice president for development and university relations
Joseph I. Goldstein, Sc.D., vice president for research
Eric V. Ottervik, Ph.D., vice president for academic services
John W. Woltjen, B.S., vice president for administration and treasurer
Michael G. Bolton, M.B.A., assistant vice president for university relations and assistant to the president
Robert M. Holcombe, M.B.A., executive secretary, board of trustees
Austin Gavin, LL.B., executive consultant
Patti T. Ota, Ph.D., associate provost
Linda T. Seeloff, M.Ed., director of institutional studies
Kathleen H. Liebhardt, M.A., assistant to the provost
Mary I. Malone, B.A., secretary to the president
Richard W. Barsness, Ph.D., dean, College of Business and Economics
Donald M. Bolle, Ph.D., dean, College of Engineering and Applied Science
John W. Hunt, Ph.D., dean, College of Arts and Science
Jerry P. King, Ph.D., dean, the Graduate School
Paul VanR. Miller, Ph.D., dean, College of Education
Curtis W. Clump, Ph.D., associate dean, College of Engineering and Applied Science
G. Mark Ellis, Ph.D., associate dean, College of Arts and Science
Steven S. Krawiec, Ph.D., associate dean, College of Arts and Science
Alan W. Pense, Ph.D., associate dean, College of Engineering and Applied Science
Joseph P. Klein, M.B.A., assistant dean, College of Business and Economics
Mark S. Lang, Ph.D., executive director, North East Tier Ben Franklin Advanced Technology Center

Offices and Resources

In this section, only the principal officers, are listed. For degree information, consult the alphabetical listing that follows.

Administrative Systems

E.W. Fairchild-Martindale Library and Computing Center 8; 758-3010

Roy A. Gruver, director

Admission

Alumni Memorial Building 27; 758-3100

Samuel H. Missimer, director

Alumni Association

Alumni Memorial Building 27; 758-3135

Donald H. Bott, executive director

Art Galleries

Chandler-Ullmann Hall 17; 758-3615

Ricardo Viera, director

Athletics and Recreation

Taylor Gymnasium 38; 758-4300

John C. Whitehead, director

Auxiliary Services

Rathbone Hall 63; 758-3514

Richard S. Metz, director
Richard H. Fritz, director of events, Stabler Athletic and Convocation Center

Bookstore
Maginnes Hall 9; 758-3375
Robert W. Bell, director

Budget
Alumni Memorial Building 27; 861-4202
James A. Tiefenbrunn, director

Bursar
Alumni Memorial Building 27; 758-3160
Joseph Petronio, bursar

Career Planning and Placement Services
Christmas-Saucon Hall 14; 758-3710
Eugene R. Seeloff, director

Central Copying and Mailing Service
Alumni Memorial Building 27; 758-3110
Wayne S. Hoffman, director
James C. Wiltraut, postmaster, university post office

Chaplaincy Services
Johnson Hall 36; 758-3877
The Rev. Hubert L. Flesher, university chaplain and professor of religion studies
The Rev. Richard A. Schware, Roman Catholic chaplain

Community Relations
436 Brodhead Ave., Bethlehem, Pa. 18015; 758-4750
James W. Harper, director

Computing and Communication Services
400 Linderman 30; 758-4750
Bruce D. Fritchman, assistant vice president

Computing Center
E.W. Fairchild-Martindale Library and Computing Center 8A; 758-3830
William R. Harris, director

Continuing Education and Summer Sessions
219 Warren Square; 758-3935; 758-3966
James A. Brown, director

Controller
Alumni Memorial Building 27; 758-3140
F. Robert Huth, Jr., controller

Counseling Service
Johnson Hall 36; 758-3880
Andrew J. Edmiston, director

Dean of Students
Packer Hall, University Center 29; 758-4156
John W. Smeaton, assistant vice president and dean of students
Terrence M. Curran, associate dean of students
Mark H. Erickson, associate dean of students
Jennifer Volchko, associate dean of students

Development
Alumni Memorial Building 27; (215) 758-3120
Paul J. Franz, Jr., vice president for development and university relations
Michael G. Bolton, assistant vice president for university relations
John T. Fulton, assistant vice president for development

Facilities Services
461 Webster St., Bethlehem, Pa. 18015; 758-3970
Anthony L. Corallo, assistant vice president
Paul T. Miller, director of physical plant
Patricia A. Chase, director, office of physical planning

Financial Aid
Alumni Memorial Building 27; 758-3181
William E. Stanford, director

Forum
Packer Hall, University Center 29; 861-4190
Marc Falato, co-chairperson (1986-87)
Robert H. Mills, co-chairperson (1986-87)

Health Center
Johnson Hall 36; 758-3870
Carl R. Ruch, M.D., director

Human Resources
(See Personnel)

Institutional Purchasing
404 Adams St., Bethlehem, Pa. 18015; 758-3840
Barry L. Gaal, director of business services

The Learning Center
Coppee Hall 33; 758-3098
Edward E. Lotto, director

Libraries
E.W. Fairchild-Martindale Library and Computing Center 8; 758-3025
Berry G. Richards, director
Lynn K. Milet, director of media services

Microcomputer Store
Sayre Building 26; 758-4606
Robert Kendi, Manager

Personnel (Human Resources)
622 Brodhead Ave., Bethlehem, Pa. 18015; 758-3900

University Police
Packer Hall, University Center 29; 758-4200
Eugene Dax, chief

Public Information
436 Brodhead Ave., Bethlehem, Pa. 18015; 758-3170
William Armold, director

University Publications
Linderman Library 30; 758-3015
George L. Beezer, director

Registrar
Alumni Memorial Building 27; 758-3200
Claire C. Biser, registrar

Office of Research
203 E. Packer Ave., Bethlehem, Pa. 18015; 861-3020
Richard B. Streeter, director

Vice President for Research
Whitaker Laboratory 5; 758-4210
Joseph I. Goldstein, vice president for research

Residence Operations
Rathbone Hall 63; 758-3500
Barbara L. Kreppel, director

Risk Management
616 Brodhead Ave., Bethlehem, Pa. 18015
Thomas J. Verbonitz, director

Student Affairs
Alumni Memorial Building 27; 758-3890
Marsha A. Duncan, vice president
John W. Smeaton, assistant vice president and dean of students
Joseph D. Sterrett, assistant vice president

Transportation Services
Murray H. Goodman Campus 126; 758-4410
Christopher J. Christian, manager

Treasurer
Alumni Memorial Building 27; 758-3180
John W. Woltjen, vice president for administration and treasurer
Richard H. Sanders, assistant vice president for financial services

North East Tier Ben Franklin Advanced Technology Center

125 Goodman Drive, Bethlehem, Pa. 18015; (215) 758-5200
Mark S. Lang, executive director

Faculty and Staff; Emeriti

The first date after the name is the date of appointment to continuous service on the Lehigh faculty or staff; the second date, when the first fails to do so, indicates the date of appointment to the present professional rank. Where the name of the institution awarding a high-level degree is not given, the institution is the same one that awarded the previous degree listed.

P.E. indicates certification as a professional engineer; C.P.A. indicates certified public accountant. A.P.R. indicates accreditation by Public Relations Society of America. A.T. C., means certified athletic trainer.

Information given is as accurate as possible. In an active university, personnel and responsibilities are subject to change on a continuing basis.

The sources of the listings are as follows: provost's office for faculty and emeriti; controller's office for members of the professional staff; office of the vice president for research, visiting research scientists, scholars or engineers and research associates; and North East Tier Ben Franklin Advanced Technology Center, staff of the center.

In the case of emeriti, the first year given is the one in which the person started at Lehigh; the last year given is the one in which emeriti status was conferred.

A

John H. Abel, Jr. (1985), chairperson and professor of biology. B.A., Wooster, 1959; M.A., Brown, 1964; Ph.D., 1966.

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Kevin J. Smith (1986), research associate, chemistry. B.S., Univ. of Natal (South Africa), 1977; M.S., 1979; Ph.D., McMaster (Canada), 1982.

Patti L. Smith (1985), adjunct lecturer of law and business. B.S., Maryland, 1974; J.D., Temple School of Law, 1981.

Penny Smith (1987), assistant professor of mathematics. B.S., Polytechnic Institute of Brooklyn, 1974; Ph.D., 1978.

Wesley R. Smith (1958, 1979), professor of physics. B.S., Lehigh, 1950; M.S., 1951; Ph.D., Princeton, 1957.

Oles M. Smolansky (1963, 1966), University Professor of international relations. B.A., New York, 1953; M.A., Columbia, 1955; Ph.D., 1959.

Mervin P. Smolinsky (1970), adjunct associate professor of psychology and education. B.A., Temple, 1951; M.S., Pittsburgh, 1966; Ph.D., 1969.

Thomas J. Smull, senior systems analyst. B.S., Lehigh, 1969.

Donald M. Smyth (1971, 1973), professor of materials science and engineering, professor of chemistry, and director, Materials Research Center. B.S., Maine, 1951; Ph.D., M.I.T., 1954.

Max D. Snider (1946, 1980), professor emeritus of marketing and associate dean emeritus of the College of Business and Economics. B.S., Illinois, 1936; M.S., 1937; M.B.A., Stanford, 1941.

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Margaret L. Snyder (1984), adjunct lecturer of Spanish. B.A., William Smith, 1969; M.A., Lehigh, 1971.

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Wilbur D. Bernhart Spatz (1946, 1973), professor emeritus of physics. B.S., Lafayette, 1930; M.S., Purdue, 1934; Ph.D., N.Y.U., 1943.

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Leslie H. Sperling (1967, 1978), professor of chemical engineering. B.S., Florida, 1954; M.A., Duke, 1957; Ph.D., 1959.

Robert S. Sprague (1957, 1981), assistant chairperson and professor of chemistry. B.S., Washington and Jefferson, 1943; Ph.D., Illinois, 1949.

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Duane E. Stackhouse (1969), associate director, health services. B.S., Juniata, 1957; M.D., Temple, 1961.

William B. Stafford (1967, 1972), associate professor of education. A.B., Ohio, 1954; M.A., 1955; Ph.D., Indiana, 1965. (On academic leave, fall, 1987)

William E. Stanford (1967, 1970), director of financial aid. B.A., Drew, 1962.

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Gilbert A. Stengle (1960, 1970), professor of mathematics. B.S., Cornell, 1954; M.S., Wisconsin, 1957; Ph.D., 1961.

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Robert D. Stout (1939, 1980), dean emeritus and professor emeritus of metallurgy and materials engineering. B.S., Penn State, 1935; M.S., Lehigh, 1941; Ph.D., 1944; D.Sc., Albright, 1967. P.E., Pennsylvania, 1946.

Carl F. Strauch (1934, 1974), Distinguished Professor Emeritus of English. A.B., Muhlenberg, 1930; M.A., Lehigh, 1934; Ph.D., Yale, 1946; D.H.L., (Hon.), Muhlenberg, 1973.

Richard B. Streeter (1979), director, Office of Research. B.A., Florida, 1962; M.Ed., 1963; Ed.D., Miami, 1972.

John Strohmeyer (1986), J.B. McFadden Distinguished Professor of Journalism. B.A., Muhlenberg, 1947; M.A., Columbia; L.H.D., Lehigh, 1983.

James E. Sturm (1956, 1972), professor of chemistry. B.A., St. John's (Minnesota), 1951; Ph.D., Notre Dame, 1957.

Duck Hyang Suh (1984, 1985), researcher in biology. M.S., Minnesota, 1979; Ph.D., Michigan, 1984.

Robert J. Sullivan (1962, 1986), professor emeritus of journalism. B.A., Syracuse, 1947; M.A., 1951.

Robert J. Suppa (1979), assistant professor of education. B.S., Edinboro State, 1966; M.Ed., 1968; M.Ed., 1972; Ed.D., Kentucky, 1981.

Alfred K. Susskind (1968), professor of electrical and computer engineering. B.E.E., Polytechnic Inst. of Brooklyn, 1948; S.M., M.I.T., 1950.

Hugh T. Sutherland (1967), instruments associate, Fritz Engineering Laboratory.

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T

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Everett A. Teal (1945, 1975), director emeritus of placement services. B.S., Ball State, 1932; M.A., Columbia, 1941.

Susan Terry (1985), assistant manager and textbook buyer.

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Eric D. Thompson (1983), professor of computer science and electrical engineering. S.B., M.I.T., 1956; S.M., 1956; Ph.D., 1960.

Robert J. Thornton (1970, 1984), chairperson and professor of economics. H.A.B., Xavier, 1965; M.A., Illinois, 1967; Ph.D., 1970. (On academic leave, fall, 1987)

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Doris M. Transue (1964), nurse, health services. R.N., St. Luke's Hospital, 1947.

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B. Thayer Turner (1970), varsity wrestling coach. B.S., Lehigh, 1961.

LeRoy J. Tuscher (1971, 1986), chairperson and professor of educational technology and computer science. B.S., Northern State, 1958; M.A., Stanford, 1964; Ph.D., Florida State, 1971.

Kemal Tuzla (1981), research engineer, Institute of Thermo-Fluid Engineering and Science. M.S., Tech. Univ. of Istanbul, 1966; Ph.D., 1972.

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U

Dean P. Updike (1965, 1980), professor of mechanical engineering and mechanics. B.S., Princeton, 1957; M.S., New York, 1960; Ph.D., Brown, 1964.

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V

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Charles H. Voas (1982), assistant professor of mathematics. B.A., North Texas State, 1975; M.S., 1976; Ph.D., Virginia, 1980. (On academic leave, spring, fall, 1987)

Weston C. Vogel, Jr. (1982), adjunct lecturer of industrial engineering. B.S., Lehigh, 1976.

Jennifer F. Volchko (1984), associate dean of students. B.A., Slippery Rock, 1976; M.A., 1978.

Arkady S. Voloshin (1984), associate professor of mechanical engineering and mechanics. Ph.D., Tel-Aviv (Israel), 1978.

Joseph A. Volpe, Jr. (1983, 1985), assistant professor of philosophy. B.A., Greensboro, 1969; B.A., Washington, 1974; Ph.D., Pennsylvania, 1985.

Frank J. Vresics (1983), admissions counselor. B.A., Lehigh, 1982.

W

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Stuart K. Webster (1972, 1981), chairperson and associate professor of accounting. B.A., Heidelberg, 1964; M.A., Bowling Green, 1965; Ph.D., Iowa, 1975. C.P.A., Iowa, 1969.

Ben L. Wechsler (1974, 1982), professor emeritus of industrial engineering. B.S., Carnegie, 1942; M.A., George Washington, 1962; Ph.D., Lehigh, 1974.

Cynthia Weeks (1984), manager of telecommunications and computer operations, Ben Franklin Advanced Technology Center.

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Fred J. Wehden (1977), laboratory and shop supervisor, mechanical engineering and mechanics.

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Walter J. Whitehead (1976), assistant football coach. B.S., Purdue, 1970.

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Amy Wittman (1986), research administrator, office of research. B.A., Emory, 1977; M.B.A., Univ. of Chicago, 1978; M.Pub.Adm., New York Univ., 1984.

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Lenora D. Wolfgang (1980, 1986), associate professor of French. B.A., Pennsylvania, 1956; M.A., 1965; Ph.D., 1973.

John W. Woltjen (1977), vice president for administration and treasurer, and secretary of the board of trustees. B.S., Moravian, 1959.

Craig F. Wood (1983), assistant controller. B.A., Moravian, 1979. C.P.A., Pennsylvania, 1984.

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Benjamin G. Wright III (1986), visiting lecturer of religion studies. B.A., Ursinus, 1975; M.Div., Eastern Baptist Theological Seminary, 1978.

Albert H. Wurth, Jr. (1985), instructor of government. B.A., Northwestern, 1971; M.A., Southern Illinois, 1981.

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Y

John J. Yanek (1986), teacher intern, Centennial School. B.S.., Indiana (Pa.), 1985.

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Sandra A. Yeager (1985), visiting engineer/scientist, chemistry. B.S., Thiel, 1960; M.S., New Hampshire, 1963; Ph.D., 1968.

Kenneth M. Yeisley (1974), assistant director, physical plant.

Ben T. Yen (1964, 1977), professor of civil engineering. B.S., National Taiwan, 1955; M.S., Lehigh, 1959; Ph.D., 1963.

Rodney Yerk (1978, 1984), assistant director, physical plant.

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Z

Ivan Zaknic (1986), associate professor of art and architecture. B.Arch., Cooper Union, 1972; M.Arch., Princeton, 1975.

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Albert C. Zettlemoyer (1941, 1982), Distinguished Professor Emeritus of Chemistry; provost and vice president emeritus. B.S., Lehigh, 1936; M.S., 1938; Ph.D., M.I.T., 1941; D.Sc. (Hon.), Clarkson, 1965; LL.D. (Hon.), The China Academy (Taiwan), 1974.

Emory W. Zimmers, Jr. (1969, 1980), professor of industrial engineering and director, industrial engineering CIM laboratory. B.S., Lehigh, 1966; B.S., 1967; M.S., 1967; Ph.D., 1973.

Carol F. Zirkel (1984), librarian, Centennial School. B.A., Connecticut, 1967; M.L.S., South Carolina State, 1968.

Perry A. Zirkel (1977, 1983), University Professor of education and law. B.A., S.U.N.Y. at Oswego, 1966; M.A., Connecticut, 1968; Ph.D. 1972; J.D., 1976; LL.M., Yale, 1983.

In Memoriam

The university records with a sense of loss the deaths of the following individuals.

Alan S. Foust, professor emeritus of chemical engineering, March 19, 1986.

Richard P. Gibney, director of intercollegiate athletics, February 25, 1986.

E. Anthony James, Professor of English, February 10, 1987.

Research Organizations/ Directors and Staff

Directors and staff members of the university's research centers and institutes are listed. Complete degree information may be found in the faculty and staff alphabetical listings. In some cases, areas of research interest are given.

All addresses are Bethlehem, Pa. 18015, and the area code is (215).

Biotechnology Research Center

Whitaker Laboratory 5; 758-4262

Arthur E. Humphrey, Ph.D., chemical engineering, *director;* modelling, monitoring and control of fermentation and enzyme processes; John H. Abel, Jr., Ph.D., cell biology; isolation, purification, characterization, synthesis and utilization of gonadotropin receptors; Jack A. Alhadeff, Ph.D., biochemistry; purification and characterization of biomedically important enzymes, proteins and glycoproteins; Barry S.. Bean, Ph.D., biology; microbial behavior and metabolism; genetics; Michael Behe, Ph.D., biochemistry; biophysical chemistry of nucleic acid and chromatin structure; Marvin Charles, Ph.D., chemical engineering; scale-up and plant design of fermentation, enzyme and separation systems; G. Doyle Daves, Ph.D., organic chemistry; isolation, structure elucidation and synthesis of natural products with important biological properties; Natalie I. Foster, Ph.D., chemistry; use of NMR and enhancement agents for medical imaging and delineation of malignancies; Ned D. Heindel, Ph.D., organic chemistry, development of therapeutic diagnostic pharmaceuticals; use of monodonal antibodies as transport vehicles for radiation sensitizers to tumors; James T. Hsu, Ph.D., chemical engineering; process technology for the separation and purification of biological molecules; Steven S. Krawiec, Ph.D., microbiology; study of the modes of growth and accretion of new genetic material by procaryotes; Linda Lowe-Krentz, Ph.D., biochemistry and molecular biology; utilization of tissue culture of animal cells for the study of cell-cell interaction and communication; Joseph R. Merkel, Ph.D., biochemistry; microbial and marine biochemistry; enzymology of collagenases; Bland S. Montenecourt, Ph.D., microbiology; study of the mechanism and genetic control of protein secretion; coupling of genetically improved microorganisms with development of products with industrial importance; Janice A. Phillips, Ph.D., chemical engineering; kinetics of fermentation, cell culture and enzyme processes; enzyme and cell immobilization; monitoring and control of fermentation and separation systems; Steven L. Regen, Ph.D., organic chemistry; synthesis and characterization of novel polymerized esicles for potential use as drug carriers, model biomembranes and catalysts for organic syntheses; James E. Roberts, Ph.D., physical chemistry; use of solid-state NMR techniques to analyze structure and/or function of solid materials including membrane proteins; Jeffrey A. Sands, Ph.D., biophysics; development and use of new gene-cloning systems for efficient production, processing and secretion of proteins; Keith J. Schray, Ph.D., organic chemistry; development of clinical assays including chemiluminescent and enzyme immunoassays; Vassie C. Ware, Ph.D., biology; study of molecular mchanisms regulating gene expression in eukaryotes; Jayantha H. Wimalasena, Ph.D., pharmacology; isolation, purification and physical-chemical characterization of gonadotropin receptors.

Center for Chemical Process Modeling and Control

Whitaker Laboratory 5; 758-4781

Christos Georgakis, Ph.D., *center director;* William L. Luyben, Ph.D., *co-director;* Carol A. Pierce, *program coordinator;* Hugo S. Caram, Ph.D.; John C. Chen, Ph.D.; Mohammed S. El-Aasser, Ph.D.; Arthur E. Humphrey, Ph.D.; Stanley H. Johnson, Ph.D.; Andrew Klein, Ph.D.; Kannan M. Moudgalya, Ph.D., research associate; Janice A. Phillips, Ph.D.; Matthew J. Reilly, Ph.D.; David A. Sanchez, Ph.D.; William E. Schiesser, Ph.D.; Harvey G. Stenger, Ph.D.; Robert H. Storer, Ph.D.; John C. Wiginton, Ph.D.

Center for Design and Manufacturing Innovation

H.S. Mohler Laboratory #200; 758-4114

Roger N. Nagel, Ph.D., *director;* Betzalel Avitzur, Ph.D.; Russell E. Benner, Ph.D., P.E.; Forbes T. Brown, Sc.D.; D. Richard Decker, Ph.D.; Fazil Erdogan, Ph.D.; Bruce D. Fritchman, Ph.D.; Christos Georgakis, Ph.D.; Mikell P. Groover, Ph.D.; Samuel L. Gulden, M.A.; Ronald J. Hartranft, Ph.D.; Donald J. Hillman, Ph.D.; Ralph J. Jaccodine, Ph.D.; Stanley H. Johnson, Ph.D.; George E. Kane, M.A., P.E.; Celal N. Kostem, Ph.D.; Mark S. Lang, Ph.D.; Arthur I. Larky, Ph.D.; Robert A. Lucas, Ph.D.; William L. Luyben, Ph.D.; Michael R. Notis, Ph.D.; John B. Ochs, Ph.D.; Nicholas G. Odrey, Ph.D.; M. Tulga Ozsoy, Ph.D.; Alan W. Pense, Ph.D.; N. Duke Perreira, Ph.D.; Louis J. Plebani, Ph.D.; Richard Roberts, Ph.D.; Guruswami Sathyanarayanan, Ph.D.; William E. Schiesser, Ph.D.; Harvey G. Stenger, Jr., Ph.D.; S. Kenneth Tarby, Ph.D.; Theodore A. Terry, Ph.D., P.E.; David A. Thomas, Sc.D.; Marvin H. White, Ph.D.; John C. Wiginton, Ph.D.; John L. Wilson, Ph.D.; John D. Wood, Ph.D.; Emory W. Zimmers, Ph.D.

Center for Economic Education

Drown Hall 35; 758-3401

Warren A. Pillsbury, Ph.D., *director;* Nicholas Balabkins, Ph.D.; Carl R. Beidleman, Ph.D.; Frank R. Gunter, Ph.D.; Jon T. Innes, Ph.D.; Arthur E. King, Ph.D.; Michael R. Hodges, Ph.D.; Thomas J. Hyclak, Ph.D.; Michael G. Kolchin, D.B.A.; Robert L. Leight, Ed.D.

Center for Health Sciences

Chandler-Ullmann Hall 17; 758-3645

Ned D. Heindel, Ph.D., *director;* John H. Abel, Ph.D.; Jack A. Alhadeff, Ph.D.; Barry S. Bean, Ph.D.; Michael J. Behe, Ph.D.; Brent W. Benson, Ph.D.; G. Doyle Daves, Jr., Ph.D.; Natalie Foster, Ph.D.; K. Elaine Hoagland, Ph.D.; Steven Krawiec, Ph.D.; Linda Lowe-Krentz, Ph.D.; Joseph R. Merkel, Ph.D.; John G. Michopoulos, Ph.D.; Bland S. Montenecourt, Ph.D.; John G. Nyby, Ph.D.; Janice A. Phillips, Ph.D.; Steven L. Regen, Ph.D.; James E. Roberts, Ph.D.; Eric P. Salathe, Ph.D.; Jeffrey A. Sands, Ph.D.; Keith J. Schray, Ph.D.; Neal G. Simon, Ph.D.; Ramamirtham Venkataraman, Ph.D.; Arkady Voloshin, Ph.D.; Vassie C. Ware, Ph.D.; S. Lloyd Williams, Ph.D.; Jayantha H. Wimalasena, Ph.D.

Center for Innovation Management Studies

Drown Hall 35; 758-3427

Alden S. Bean, Ph.D., *director;* J. Richard Aronson, Ph.D.; Richard W. Barsness, Ph.D.; John W. Bonge, Ph.D.; Donald T. Campbell, Ph.D.; Steven L. Goldman, Ph.D.; John B. Guerard, Ph.D; Roy C. Herrenkohl, Ph.D.; Donald J. Hillman, Ph.D.; James B. Hobbs, D.B.A.; Raymond L. Horton, Ph.D.; Thomas J. Hyclak, Ph.D.; George E. Kane, M.S.; Michael G. Kolchin, D.B.A.; James A. Largay, Ph.D.; Benjamin Litt, Ph.D.; Bruce M. Smackey, Ph.D.; John C. Wiginton, Ph.D.

Center for International Studies

215 Maginnes Hall #9; 758-4745

Z. J. Slouka, Ph.D., *director;* David W. Lewis, Ph.D., executive director; Carl R. Beidleman, Ph.D.; Raymond Bell, Ph.D.; Stephen H. Cutcliffe, Ph.D.; Steven L. Goldman, Ph.D.; Michael R. Notis, Ph.D.; Jean C. Oi, Ph.D.; Donald O. Rockwell, Ph.D.

Center for Social Research

10 W. Fourth St.; 758-3800

Roy C. Herrenkohl, Ph.D., *director;* Arthur E. King, Ph.D., assistant director; Janice M. Alhadeff, M.A., research scientist; Thomas O. Blank, Ph.D.; Donald T. Campbell, Ph.D.; Brenda P. Egolf, M.A., research scientist; John B. Gatewood, Ph.D.; Ellen C. Herrenkohl, Ph.D., research scientist; Patricia J. Horton, Ph.D., research scientist; Raymond L. Horton, D.B.A.; Thomas J. Hyclak, Ph.D.; Diane T. Hyland, Ph.D.; Michael G. Kolchin, Ph.D.; Judith N. Lasker, Ph.D.; Vincent G. Munley, Ph.D.; Sandra L. Pipp, Ph.D.; Kandi M. Stinson, Ph.D.

Center for Surface and Coatings Research

Sinclair Laboratory 7; 758-3571

Gary W. Simmons, Ph.D., *director;* Eugene M. Allen, Ph.D., professor emeritus of chemistry; Robert P. Eischens, adjunct faculty; Frederick M. Fowkes, Ph.D., professor emeritus of chemistry; Kamil Klier, Ph.D., professor of chemistry and director, catalysis laboratory; John W. Larsen, Ph.D., professor of oganic chemistry; Henry Leidheiser, Jr., Ph.D., professor of chemistry and *director,* corrosion laboratory; Charles E. Lyman, Ph.D., associate professor of metallurgy and materials engineering; Fortunato J. Micale, Ph.D., professor of chemistry and *director,* colloid laboratory; Steven L. Regen, Ph.D., professor of organic and polymer chemistry; Gary W. Simmons, Ph.D., professor of chemistry and *director,* surface analysis laboratory; Harvey G. Stenger, Jr., assistant professor of chemical engineering; Robert P. Wei, Ph.D., professor of mechanical engineering and mechanics and *director,* environment-sensitive fracture laboratory; Albert C. Zettlemoyer, university distinguished professor and provost emeritus; Abdolhossein Alavi, Ph.D.; Richard D. Granata, Ph.D.; Richard G. Herman, Ph.D.; S-H. Scott Kuo, Ph.D.; Andries D. Sebastian, Ph.D.; Malcolm L. White, Ph.D.; Ren Jun Zhou, Ph.D.

Center for the Application of Mathematics

Linderman Library 30, Bethlehem, Pa. 18015 (215) 758-3805

Gerald F. Smith, Ph.D., *director;* Philip A. Blythe, Ph.D.; Dominic G.B. Edelen, Ph.D.; Gregory T. McAllister, Jr., Ph.D.; Eric P. Salathe, Ph.D.; Anastasios Kydoniefs, Ph.D.; Ronald S. Rivlin, Sc.D., adjunct professor; Kenneth N. Sawyers, Ph.D.; Jacob Y. Kazakia, Ph.D.; Alister K. Macpherson, Ph.D.; David A. Walker, Ph.D.; Ramamirtham Venkataraman, Ph.D.; Daniel J. Yaniro, Jr., Ph.D.

Division of Bioengineering

Eric P. Salathe, Ph.D., division *director;* mathematical modeling in circulatory system; John G. Michopoulos, Ph.D., high-voltage electrophotography applied to detect damage in bones and tissues; George C. M. Sih, Ph.D., material for artificial limbs, prosthetic apparatus; Ramamirtham Venkataraman, Ph.D., mathematical modeling

Division of Biological Chemistry and Biophysics

Keith J. Schray, Ph.D., division *director;* intermediary metabolism; enzyme kinetics, enzyme immunoassay; Paul Adolf, Ph.D., clinical chemistry; Jack A. Alhadeff, Ph.D., biochemistry of human metabolic diseases; Barry S. Bean, Ph.D., microbial metabolism and genetics; Brent W. Benson, Ph.D., radiation biophysics; structure of nucleic acids; G. Doyle Daves, Jr., Ph.D., structure and properties of biomolecules; H. Donald Burns, Ph.D., nuclear medicine; Natalie M. Foster, D.A., Ph.D., radiopharmaceutical syntheses; Ned D. Heindel, Ph.D., medicinal chemistry; nuclear medicine; cancer chemotherapy; bioorganic chemistry; Steven S. Krawiec, Ph.D., microbial ecology; DNA encapsulation; K. Elaine Hoagland, Ph.D., reproductive strategies; Bland S. Montenecourt, Ph.D., microbial biochemistry and genetics; John G. Nyby, Ph.D., behavioral endocrinology; Jeffrey Sands, Ph.D., biophysics of viruses; Neal G. Simon, Ph.D., neuroendocrinology; David V. Woo, Ph.D., radiopharmacology.

Educational Service Bureau

524 Brodhead Ave.; 758-3237

Charles W. Guditus, Ed.D., clinical supervision; Fenwick W. English, Ph.D., personnel administration; Perry A. Zirkel, Ph.D., J.D., school law

Emulsion Polymers Institute

Sinclair Laboratory 7; 758-3590

Mohamed S. El-Aasser, Ph.D., *co-director;* John W. Vanderhoff, Ph.D., *co-director;* Andrew Klein, Ph.D.; Frederick M. Fowkes, Ph.D.; Christos Georgakis, PhD.; John A. Manson, Ph.D.; Fortunato J. Micale, Ph.D.; Cesar Silebi, Ph.D.; E. David Sudol, Ph.D.; Victoria Dimonie, Ph.D.; Keith Schray, Ph.D.; Ken Chiang, Ph.D.; Eric S. Daniels; Olga Shaffer.

Energy Research Center

Packard Laboratory 19; 758-4090

Edward K. Levy, Ph.D., *director;* Betzalel Avitzur, Ph.D.; Osama A. Badr, Ph.D.; Russell E. Benner, Ph.D.; Patricia Bradt, Ph.D.; Hugo S. Caram, Ph.D.; John C. Chen, Ph.D.; Terry J. Delph, Ph.D.; Fazil Erdogan, Ph.D.; Frederick M.

Fowkes, Ph.D.; Sharon Friedman, M.A.; Christos Georgakis, Ph.D.; Bruce R. Hargreaves, Ph.D.; Roy C. Herrenkohl, Ph.D.; K. Elaine Hoagland, Ph.D.; Michael R. Hodges, Ph.D.; Stanley H. Johnson, Ph.D.; Alvin S. Kanofsky, Ph.D.; Irwin Kugelman, Ph.D.; John Larsen, Ph.D.; Gerard P. Lennon, Ph.D.; Arnold R. Marder, Ph.D.; John R. McNamara, Ph.D.; Bland S. Montenecourt, Ph.D.; Sudhakar Neti, Ph.D.; Alexis Ostapenko, Ph.D.; Jerzy Owczarek, Ph.D.; Alan W. Pense, Ph.D.; Donald O. Rockwell, Ph.D.; Jeffrey A. Sands, Ph.D.; Nenad Sarunac, Ph.D.; John Sculac, M.S.; Dale R. Simpson, Ph.D.; Bruce M. Smackey, Ph.D.; Bruce R. Somers, Ph.D.; Fred P. Stein, Ph.D.; Harvey G. Stenger, Jr., Ph.D.; Robert D. Stout, Ph.D.; Robert P. Wei, Ph.D.; David B. Williams, Ph.D.; John D. Wood, Ph.D.; Arthur S. Warnock, Ph.D.

Engineering Research Center for Advanced Technology for Large Structural Systems (ATLSS)

Fritz Engineering Laboratory 13; 758-3535

John W. Fisher, Ph.D., *director;* Alan W. Pense, Ph.D., associate director; John E. Bower, Ph.D., deputy director; Peter Mueller, Dr.Sc.Tech., structural design; David A. Thomas, Sc.D., materials engineering; Mikell P. Groover, Ph.D., manufacturing processes; John L. Wilson, Ph.D., computer technology; Henry Leidheiser, Jr., Ph.D., in-service performance; Carl R. Beidleman, Ph.D., business studies.

Environmental Studies Center

Chandler-Ullmann Hall; 758-3670

Irwin J. Kugelman, Sc.D., *director;* Patricia T. Bradt, Ph.D., research scientist; Bobb Carson, Ph.D., oceanic sedimentology; Edward B. Evenson, Ph.D., environmental geology; Hsai-Yang Fang, Ph.D., environmental geotechnology; John Gatewood, Ph.D., social relations; Vincent G. Guida, Ph.D., environmental ecology; Bruce R. Hargreaves, Ph.D., physiological ecology; K. Elaine Hoagland, Ph.D., research scientist; Robert L. Johnson, Ph.D., environmental engineering; Arthur E. King, Ph.D., economics; Gerard P. Lennon, Ph.D., groundwater hydrology; John R. McNamara, Ph.D., economics; Joseph R. Merkel, Ph.D., marine biochemistry; Fortunato Micale, Ph.D., chemistry; Vincent Munley, Ph.D., economics; Sibel Pamukcu, Ph.D., geotechnology; Jon I. Parker, Ph.D., biology; James M. Parks, Ph.D., coastal sedimentation; Hayden N. Pritchard, Ph.D., botany; Arup K. Sengupta, Ph.D., environmental engineering; Robert M. Sorensen, Ph.D., coastal engineering; Richard N. Weisman, Ph.D., hydrology; Craig E. Williamson, Ph.D., biology

Fairchild-Martindale Center for the Study of Private Enterprise

Drown Hall 35; 758-4711

J. Richard Aronson, Ph.D., *director;* Robert J. Thornton, Ph.D., associate director; Kenneth P. Sinclair, Ph.D., associate director; Thomas J. Hyclak, Ph.D., assistant director; Michael G. Kolchin, D.B.A., assistant director; Richard W. Barsness, Ph.D.; Carl R. Beidleman, Ph.D.; Brian G. Brockway, J.D.; Michael L. Davis, Ph.D.; Frank R. Gunter, Ph.D.; James M. Maskulka, D.B.A.; John R. McNamara, Ph.D.; Vincent G. Munley, Ph.D.; Jon T. Innes, Ph.D.; Alvin Cohen, Ph.D.; James A. Hall, Ph.D.

Fritz Engineering Laboratory

Fritz Engineering Laboratory 13; 758-3537

Irwin J. Kugelman, Sc.D., *director;* Bruce A. Laub, M.B.A., administrative associate; George C. Driscoll, Ph.D., *director,* structural connections division; Hsai-Yang Fang, Ph.D., *director,* geotechnical engineering division; John W. Fisher, Ph.D., *director,* fatigue and fracture division; Ti Huang, Ph.D., *director,* structural concrete division; Le-Wu Lu, Ph.D., *director,* earthquake engineering division; Alexis Ostapenko, Ph.D., *director,* structural stability division; Roger G. Slutter, Ph.D., *director,* operations division; Robert M. Sorensen, Ph.D., *director,* hydraulics division; Celal N. Kostem, Ph.D., chairperson, computer systems group; Hugh T. Sutherland, instruments associate; Lynn S. Beedle, Ph.D., associate; J. Hartley Daniels, Ph.D., associate; Robert L. Johnson, Ph.D., associate; Gerard P. Lennon, Ph.D., associate; Peter Mueller, Ph.D., associate; Sibel Pamukcu, Ph.D., associate; Alan W. Pense, Ph.D., associate; Richard Roberts, Ph.D., associate; Arup Sengupta, Ph.D., associate; Richard N. Weisman, Ph.D., associate; John L. Wilson, Ph.D., associate; Ben T. Yen, Ph.D., associate

Institute for Metal Forming

Whitaker Laboratory 5; 758-4234

Betzalel Avitzur, Ph.D., *director;* Ye T. Chou, Ph.D.; Samy Talbert, Ph.D., adjunct; Chester J. Van Tyne, Ph.D., adjunct

Institute for Robotics

H.S. Mohler Laboratory #200; 758-4826

Roger N. Nagel, Ph.D., *director;* Richard Roberts, Ph.D., associate director; Nicholas G. Odrey, Ph.D., director of robotics laboratory; Carlos M. Gomez, M.B.A., administrative associate; Forbes T. Brown, Sc.D.; Bruce D. Fritchman, Ph.D.; Samuel L. Gulden, M.A.; Mikell P. Groover, Ph.D.; Donald J. Hillman, M.Litt.; Stanley H. Johnson, Ph.D.; Andrew J. Kasarda, Ph.D.; Keith A. Krenz, M.S., research engineer; Mark S. Lang, Ph.D.; Arthur I. Larky, Ph.D.; Robert A. Lucas, Ph.D.; John B. Ochs, Ph.D.; N. Duke Perreira, Ph.D.; Louis J. Plebani, Ph.D.; Herbert Rubenstein, Ph.D.; Theodore A. Terry, Ph.D.; Marvin H. White, Ph.D.; Emory W. Zimmers, Ph.D.

Institute for the Study of the High-Rise Habitat

Fritz Engineering Laboratory 13; 758-3515

Nicholas Adams, Ph.D.; Lynn S. Beedle, Ph.D., *director;* V. Tuncer Akiner, Ph.D.; David C. Amidon, Jr., M.A.; Thomas O. Blank, Ph.D.; George C. Driscoll, Ph.D.; James A. Hall, Ph.D.; Francis A. Harvey, Ed.D.; Roy C. Herrenkohl, Ph.D.; Donald J. Hillman, Ph.D.; Ti Huang, Ph.D.; Celal N. Kostem, Ph.D.; Irwin J. Kugelman, Sc.D.; Le-Wu Lu, Ph.D.; Peter Mueller, Dr.Sc.tech; Warren A. Pillsbury, Ph.D.; Roger D. Simon, Ph.D.; Robert C. Williamson, Ph.D.; John L. Wilson, Ph.D.

Institute of Fracture and Solid Mechanics

Packard Laboratory 19; 758-4130

George C.M. Sih, Ph.D., *director;* Fazil Erdogan, Ph.D.; Ronald J. Hartranft, Ph.D.; John G. Michopoulos, Ph.D.; Robert A. Lucas, Ph.D.; Richard Roberts, Ph.D.; Robert G. Sarubbi, Ph.D.; Dean P. Updike, Ph.D.; Robert P. Wei, Ph.D.

Institute of Thermo-Fluid Engineering and Science

Whitaker Laboratory 5; 758-4091

John C. Chen, Ph.D., *director;* Philip A. Blythe, Ph.D.; Forbes T. Brown, Ph.D.; Hugo Caram, Ph.D.; Curtis W. Clump, Ph.D.; Christos Georgakis, Ph.D.; Edward K. Levy, Ph.D.; William L. Luyben, Ph.D.; Alister K. Macpherson, Ph.D.; Sudhakar Neti, Ph.D.; Jerzy A. Owczarek, Ph.D.; Donald O. Rockwell, Ph.D.; Robert G. Sarubbi, Ph.D.; William E. Schiesser, Ph.D.; Cesar A. Silebi, Ph.D.; Charles R. Smith, Ph.D.; Wesley R. Smith, Ph.D.; Frank P. Stein,

Ph.D.; Kyra Stephanoff, Ph.D.; Kemal Tuzla, Ph.D.; Ramamirtham Venkataraman, Ph.D.; Leonard A. Wenzel, Ph.D.

Lawrence Henry Gipson Institute for Eighteenth-Century Studies

Maginnes Hall 9; 758-3366

Jan Fergus, Ph.D., *co-director;* James S. Saeger, Ph.D., *co-director;* Michael D. Baylor, Ph.D.; Edward J. Gallagher, Ph.D.; John W. Hunt, Ph.D.; E. Anthony James, Ph.D.; Lawrence H. Leder, Ph.D.; D. Alexander Waldenrath, Ph.D.

Lehigh Valley Center for Jewish Studies

321 Maginnes Hall 9; 758-4869

Laurence J. Silberstein, Ph.D., *director;* Myra Rosenhaus, Ph.D., program administrator; David C. Amidon Jr., M.A.; Alice L. Eckardt, M.A.; Elizabeth N. Fifer, Ph.D.; Hubert L. Flesher, M.A.; Steven L. Goldman, Ph.D.; Harriet L. Parmet, M.Sc.Ed.; Oles M. Smolansky, Ph.D.

Materials Research Center

Coxe Laboratory 32; 758-3850

Donald M. Smyth, Ph.D., *director;* Gary A. Miller, Sc.D., *associate director* and *director,* materials liaison program; Sidney R. Butler, Ph.D., *director,* electronic materials laboratory; Helen M. Chan, Ph.D., ceramics research laboratory; Guy M. Connelly, M.S., mechanical behavior laboratory; Frank J. Feigl, Ph.D., electronic materials laboratory; Joseph I. Goldstein, Sc.D., electron optical laboratory; Martin P. Harmer, Ph.D., ceramics research laboratory; Richard W. Hertzberg, Ph.D., *director,* mechanical behavior laboratory; Himanshu Jain, Ph.D., ceramics research laboratory; Joseph F. Libsch, Sc.D.; Charles E. Lyman, Ph.D., electron optical laboratory; John A. Manson, Ph.D., *director,* polymer laboratory; Chrystal H. Newton, Ph.D., mechanical behavior laboratory; Michael R. Notis, Ph.D., *director,* ceramic research laboratory; Richard Roberts, Ph.D., mechanical behavior laboratory; Leslie H. Sperling, Ph.D., polymer laboratory; David A. Thomas, Sc.D., polymer laboratory; David B. Williams, Ph.D., *director,* electron optical laboratory

Rauch Center for Executive Development

Johnson Hall 36; 758-3432

Richard W. Barsness, Ph.D., *director;* June A. West, M.Ed., *director,* managerial communications program

Sherman Fairchild Center for Solid-State Studies

Sherman Fairchild Laboratory 161; 758-3950

Ralph J. Jaccodine, Ph.D., *director,* and Sherman Fairchild Professor of Solid-State Studies; Sidney R. Butler, Ph.D.; Walter E. Dahlke, Ph.D.; Richard D. Decker, Ph.D.; Gary G. DeLeo, Ph.D.; Frank J. Feigl, Ph.D.; W. Beall Fowler, Ph.D.; Karl H. Norian, Ph.D.; Wesley R. Smith, Ph.D.; Donald M. Smyth, Ph.D.; Jean Toulouse, Ph.D.; Marvin H. White, Ph.D., Sherman Fairchild Professor of Solid-State Studies; George D. Watkins, Ph.D., Sherman Fairchild Professor of Solid-State Studies; Donald R. Young, Ph.D.

Small Business Development Center

412 S. New St.; 758-3980

John W. Bonge, Ph.D., *director;* John E. Stevens, Ph.D., associate director; Edith D. Ritter, M.B.A., program administrator; James A. Talbott, M.B.A., associate administrator; Mehdi Hojjat, M.D., coordinator of international trade development program; George W. Miller, III, M.B.A., coordinator of government procurement assistance program

Stone Harbor Marine Laboratory

Chandler-Ullmann Hall 17; 758-3670 (research inquiries)
Stone Harbor, N.J. 08247 (609) 368-5354 (public education)

Murray Itzkowitz, Ph.D., *director;* behavioral ecology of fishes and shore birds; Charles Wahle, Ph.D., associate director, benthic invertebrate ecology; Bobb Carson, Ph.D., geological oceanography; Elizabeth Chornesky, Ph.D., invertebrate benthic ecology; John B. Gatewood, Ph.D., anthropology of marine commercial fishermen and anglers; Vincent G. Guida, Ph.D., physiology of oceanic and marine animals, ecology of symbiosis and parasitism; Bruce R. Hargreaves, Ph.D., environmental physiology; K. Elaine Hoagland, Ph.D., marine ecology and reproductive strategies; Robert L. Johnson, Ph.D., tertiary sewage treatment; Gerard P. Lennon, Ph.D., ground water hydrology and coastal engineering; Joseph R. Merkel, Ph.D., biochemistry of marine bacterial enzymes; James M. Parks, Ph.D., beach preservation; Robert Sorensen, Ph.D., coastal structures, shore-structures interactions; Richard N. Weisman, Ph.D. surface hydrology and coastal engineering

Technology Studies Resource Center/Science, Technology and Society Program

Maginnes Hall 9; 758-3550, 3551

Stephen H. Cutcliffe, *director,* Technology Studies Resource Center; Steven L. Goldman, *director,* Science, Technology and Society Program; R. Nicholas Adams, art and architecture; Rosemarie Arbur, English; Nicholas Balabkins, economics; Robert F. Barnes, philosophy and computer science and electrical engineering; Alden S. Bean, management and marketing; Lynn S. Beedle, civil engineering; Thomas O. Blank, social relations; Donald M. Bolle, electrical engineering; Patricia T. Bradt, research scientist; Arthur L. Brody, psychology; Donald T. Campbell, social relations and psychology; Jack A. DeBellis, English; John H. Ellis, history; Edward B. Evenson, geological sciences; Hubert L. Flesher, religion studies; Barbara B. Frankel, social relations; Sharon M. Friedman, journalism; Edward J. Gallagher, English; Norman J. Girardot, religion studies; Mikell P. Groover, industrial engineering; John E. Hare, philosophy; Robert Harson, English; Francis A. Harvey, education; Ned D. Heindel, chemistry; Roy C. Herrenkohl, social relations; R. Wayne Kraft, materials science and engineering; Irwin J. Kugelman, civil engineering; Judith N. Lasker, social relations; Benjamin Litt, management and marketing; John R. McNamara, economics; Norman P. Melchert, philosophy; Jeffrey Milet, speech and theater; Roger N. Nagel, computer science and electrical engineering; Michael R. Notis, materials science and engineering; Alan W. Pense, materials science and engineering; Richard J. Redd, art and architecture; Christine M. Roysdon, Linderman Library; Paul F. Salerni, music; William E. Schiesser, chemical engineering; Charles B. Sclar, geological sciences; George K. Shortess, psychology; Roger D. Simon, history; Zdenek J. Slouka, international relations; Bruce M. Smackey, management and marketing; LeRoy J. Tuscher, education; Ricardo Viera, art and architecture; Leonard Wenzel, chemical engineering; Albert H. Wurth, government; Raymond F. Wylie, international relations.

Honorary Degree Recipients

Lehigh University awarded honorary degrees to the following individuals during the past year. Where a year of graduation follows the name, the earned degree was from Lehigh.

Founder's Day, 1986

Doctor of Engineering
Herbert R. Imbt, '38, chairman of the board, Herbert R. Imbt, Inc. A former president of the Associated Pennsylvania Constructors, he worked for the highway testing laboratory of the Pennsylvania Department of Highways, and received several honors as a member of the U.S. Army Corps of Engineers. He was a member of the state General Assembly before establishing a construction business.

Doctor of Laws
Walter Burke, president, Sherman Fairchild Foundation Inc. A trustee of the Metropolitan Museum of Art, in New York City, and a trustee of the Union Theological Seminary, he is a former trustee and chairman of the board of Dartmouth College, his alma mater. He earned the LL.B. from Columbia Law School.

Doctor of Laws
Roland W. Schmitt, senior vice president and chief scientist for General Electric Co., in Schenectady, N.Y. A fellow of the American Academy of Arts and Sciences, and the American Physical Society, he earned degrees from the University of Texas and Rice University.

Commencement, 1986

Doctor of Humane Letters
The Very Rev. Daniel G. Gambet, president, Allentown College of St. Francis de Sales. Chairman of Lehigh's visiting committee for religious studies, he has served as chairman of the visiting committee for the classics and modern foreign languages. He has been recognized for his leadership in various educational and community services.

Doctor of Science
Chien-Shiung Wu, Michael I. Pupin Professor of Physics Emeritus, Columbia University. Called "the first lady of physics research," her experiment on radioactive decay of cobalt-60 overthrew one of the most fundamental laws of physics. At Columbia, she worked on the Manhattan Project, helping to invent and develop the atomic bomb. She was the first female to receive the prestigious Comstock prize, awarded only once every five years.

Doctor of Science
Charles C. Price, Benjamin Franklin Professor of Chemistry Emeritus, University of Pennsylvania. An eminent scholar, he is the founder of Academic Leaders for Alternatives to War. In 1984, he led to Moscow a delegation of the World Federalist Association, hosted by the Soviet Peace Committee, to discuss peace and disarmament with nine Soviet groups.

Doctor of Laws
Jeanette F. Reibman, Pennsylvania state senator, 18th District, Northampton County. Admitted to practice before the U.S. Supreme Court, she has served as a member of several advisory committees, such as teacher education, working conditions for women and children, and family counseling. A member of the Hunter College Hall of Fame, she received the A.B. from Hunter, and the J.D. from Indiana University School of Law.

Doctor of Laws
Franklin H. Williams, president and trustee, The Phelps-Stokes Fund. He was assistant special counsel to the National Association for the Advancement of Colored People, and he continues to be active in the advancement of educational opportunities for American minorities and Africans. As assistant attorney general of California, he established the first state constitutional rights sectionin the nation. In 1965, he served as U.S. ambassador to Ghana and received an award from the State Department for his contributions there.

Doctor of Laws
William W. Scranton, III, lieutenant governor of Pennsylvania. Businessman, editor, and journalist, he served two terms as Pennsylvania's youngest lieutenant governor. In that capacity, he served as chairman of the the bipartisan National conference of Lieutenant Governors. As chairman of the Governor' Energy Council, he led Pennsylvania to its first comprehensive energy policy and formed the Electric Utility Efficiency Task Force.

Recognition of Achievement

At the end of each semester, the dean of students publishes a list of all regular undergraduates who during that semester achieved a scholastic average of 3.50 or better and carried at least twelve credit hours of regularly graded courses (A, B, C, D, F). This is the dean's list.

Other student prizes and awards are announced at commencement exercises held on both Founder's Day, which is the second Sunday in October, at the Honors Convocation for juniors and seniors held in the spring, and on University Day in May or June. A description of the annual prizes and awards follows.

Alpha Epsilon Delta Award. The name of the premedical biology freshman with the highest cumulative average is placed on a plaque in the department of biology.

Alpha Kappa Psi Key. The Alpha Sigma Chapter of Alpha Kappa Psi, a professional fraternity in commerce, awards its scholarship key to the senior pursuing a degree in the College of Business and Economics who has attained the highest scholastic average for three years of collegiate work at Lehigh.

Alpha Pi Mu Prize. The honorary fraternity in industrial engineering awards each year an industrial engineers' handbook to a high-ranking sophomore with demonstrated interest in the industrial engineering curriculum.

Alumni Association Prizes. Funds are provided for three cash prizes. Prizes are awarded to the highest-ranking juniors in each undergraduate college.

American Chemical Society Award. The Lehigh Valley section of the American Chemical Society awards a membership in the society and a subscription to its journal to an outstanding senior in chemistry or chemical engineering.

Medal of the Philadelphia Chapter, American Institute of Chemists. This medal is awarded to the academically highest ranking senior majoring in chemistry or chemical engineering.

American Society of Civil Engineers Prize. The Lehigh Valley Section of the American Society of Civil Engineers offers a prize of a junior membership in the society to the outstanding senior in civil engineering holding membership in the student chapter.

American Society of Mechanical Engineers Associate Membership Prize. The Anthracite-Lehigh Valley Section of the American Society of Mechanical Engineers awards to an outstanding member of the Lehigh University Student Section ASME an associate membership for one year in the parent society.

American Society for Testing Materials Student Memberships Prize. Four student memberships are awarded to students who in their junior year have demonstrated interest and meritorious work in the engineering courses that are related to the ASTM.

Ferdinand P. Beer Award. An outstanding senior in mechanics receives this award named for the university distinguished professor emeritus of mechanical engineering and mechanics.

Bethlehem Fabricators Award. This tuition award is made to the junior who has shown the most improvement in academic achievement over sophomore and junior years.

The Robert W. Blake Memorial Prize. This prize is awarded at Founder's Day exercises to a freshman who has completed one year of studies in the College of Arts and Science and who is recommended by the college faculty as the most outstanding in high scholastic achievement and in promise of leadership.

Nelson Leighton Bond 1926 Memorial Award. This award is made to an outstanding sophomore on the basis of character, leadership, and scholastic achievement but not financial need. Nelson L. Bond was a prominent alumnus.

The John B. Carson Prize. A prize was established by Mrs. Helen Carson Turner, of Philadelphia, in memory of her father, John B. Carson, whose son, James D. Carson, was a graduate of the civil engineering curriculum in 1876. It is awarded to the senior in civil engineering who shows the most marked excellence in professional courses.

The William H. Chandler Prizes in Chemistry. Four prizes, one in each class, for excellence in the chemistry and chemical engineering curricula were established by Mrs. Mary E. Chandler, widow of Dr. William H. Chandler, who was professor of chemistry from 1871 until his death in 1906.

The N.I. Stotz and D.E. Rickert Choral Cup. The choral cup provided by Norman I. Stotz, Jr., '53, and Donald E. Rickert, '53, is awarded to the outstanding senior participating in the choral organizations of the music department.

The R.K. Burr and J.D. Kirkpatrick Concert Cup. The concert cup provided by Richard K. Burr, '53, and J. Donald Kirkpatrick, '55, is awarded to the outstanding senior(s) participating in the band or other instrumental organizations of the music department.

The Cornelius Prize. The Cornelius Prize established by William A. Cornelius, M.S. 1889, and endowed by a bequest by his widow, Mrs. Eleanor R.W. Cornelius, is awarded to the senior student in mechanical engineering who is judged to have profited most by opportunities at Lehigh. The award is based 70 percent on scholarship, 20 percent on attainment in general culture, and 10 percent on development in personality. To be eligible, a student's scholastic standing must be in the top quarter of the class in the College of Engineering and Applied Science.

Robert Cutler Senior Cup. To a senior member of the choir for his or her outstanding service to the choir. Robert B. Cutler is professor emeritus of music.

Alpha A. Diefenderfer Award. In recognition of the late Professor A.A. Diefenderfer's long service as faculty adviser to the organization, the Lehigh University Chemical Society established this award for the highest-ranking junior in analytical chemistry.

Aurie N. Dunlap Prize in International Relations. The prize is awarded by the international relations department to an outstanding senior in international relations. Among the criteria used to select the winner (or winners) are the following: cumulative average in international relations courses (minimum 3.5 cumulative average is required); over-all scholarly standing; number of international relations courses taken;

activities on the campus related to appreciation of international relations by the Lehigh community; and the contribution to university life. Dr. Dunlap was professor of international relations.

The Philip Francis du Pont Memorial Prize in Electrical Engineering. The Philip F. du Pont Memorial Prize Fund was established in 1929 by L.S. Horner, 1898. The income of this fund is awarded in the way of prizes, two-thirds to the highest-ranking senior and one-third to the second-highest-ranking senior in electrical engineering.

Jonathan B. Elkus Freshman Music Cup. This is awarded to a full-time freshman on the basis of membership in marching and concert band, over-all musical ability, demonstrated leadership, and exceptional psyche. Elkus was director of the marching band.

Eta Kappa Nu Prize. The honorary fraternity in electrical engineering awards a handbook in electrical engineering to the highest-ranking freshman in electrical and computer engineering.

Financial Executive Award. The award is made to a first-semester senior awarded on basis of outstanding achievement in accounting and/or finance, promise of future success and intent to seek a career in corporate accounting or financial management.

Fraternity Alumni Advisory Council Scholarship Improvement Award. This trophy is awarded to the fraternity chapter whose scholastic average for the year is most improved over the previous year.

Joseph C. Gabuzda Jr. Memorial Award. The award is presented to a deserving junior in electrical or computer engineering who has shown outstanding promise intellectually and in leadership qualities.

German Prize. The prize is awarded to seniors who are excellent in German language or culture or performing outstanding service to German culture and civilization.

Gipson Institute Undergraduate Essay Prize. This prize is awarded for the best undergraduate paper dealing with an 18th Century topic. The Lawrence Henry Gipson Institute for Eighteenth-Century Studies was endowed by a Lehigh professor who won the Pulitzer Prize.

The Gold-Hansen Trophy. Provided by Stephen R. Gold, '60, and Robert A. Hansen, '60, the trophy is awarded to a student of at least four semesters' standing with the band who has shown outstanding merit in other ways than musical or marching performance.

Malcolm J. Gordon, Jr., Physics Prize. An award is made to the highest-ranking sophomore physics major, with some extracurricular activity.

Handwerk Prize. The award is made to a student for outstanding achievement in the fields of chemistry, metallurgy or geological sciences.

The Bill Hardy Memorial Prize. An award is given by Mr. and Mrs. D. Edson Hardy in memory of their son. The recipient is the junior who most nearly reflects the qualities that typified Bill Hardy, who was outstanding in many activities, academic and otherwise.

George D. Harmon Memorial Award. An award to an outstanding senior in the history department is named for a former professor of history.

Haskins and Sells Foundation Award. An award of $500 is made to an accounting student in the College of Business and Economics or the College of Arts and Science who after three years has demonstrated excellence in scholarship, professional potential, extracurricular activities, and moral character.

David Hellekjaer Memorial Award. The friends of Dave Hellekjaer, '80 (1958-1980), created an award in his memory. It is presented to a senior who best exemplifies his characteristics, viz.: vigorous participation in sports, dedicated commitment to the study of the natural or physical sciences (biology, geology, environment science, physics or chemistry), and loyalty and contribution to a fraternity or sorority.

Joseph C. Hendrzak Memorial Award. The award is made to an outstanding senior in military science.

Donnel Foster Hewett Award. This is awarded to the senior in geology or geological sciences who has demonstrated the greatest potential for a professional career in the earth sciences.

The Harold J. Horn Prize. The heirs of Harold J. Horn, 1898, established a fund, the income of which is used in the award of a first and second prize, for the two highest-ranking juniors in electrical engineering.

Mary O. Hurley Women's Athletic Award. To a woman undergraduate who demonstrates sportsmanship, a cooperative attitude, and an enjoyment of sports with her fellow students.

Institute of Internal Auditors Award. The award is made to an outstanding senior interested in auditing.

Kappa Alpha Glee Club Senior Cup. The cup is awarded to a senior for outstanding service to the Glee Club.

The Andrew Wilson Knecht III Memorial Award. This award is made to the member of the mechanical engineering class graduating in May or June who has exhibited the greatest potential for applying technical training to practical application. The award is an engraved medallion.

Kodak Scholar Awards. These awards are made to second-semester freshmen each year who plan to major in engineering fields other than civil engineering. They cover 75 percent of tuition costs.

Arnie Lasser Award. This award is made to an outstanding undergraduate athlete in football or wrestling from the New York metropolitan area, regardless of need.

Lehigh Women's Club Prize. A junior with academic excellence and outstanding service to Lehigh is selected.

James J. Mahlbacher Prize. A football player of outstanding ability is chosen upon recommendation of coach and athletic directory.

Mathematics Faculty Award. This award, made possible by a fund established by the faculty members of the department of mathematics, is made to an outstanding junior majoring in mathematics or statistics.

Joseph A. Maurer Classics Prize. The award made to graduating seniors in two areas: first, to the major in classics for excellence in the Latin and Greek languages, and second, to the major in classical civilization for excellence in that aspect of classical

studies. Joseph A. Maurer is professor emeritus of classics.

Merck Index Award. A copy of the Merck Index is awarded by Merck and Co., Inc., to a senior in chemistry who is an outstanding student; who has been active in student society affairs; and who has promise of a successful career in chemistry in the judgment of the faculty of the chemistry department.

J. Robert Munford Award. The award is made to the geology senior who has shown the greatest improvement in over-all performance.

National Association of Accountants Award. The award is made to an outstanding accounting student.

The Elizabeth Major Nevius Award. Established by Walter I. Nevius, '12, "in loving memory of his wife, who profoundly admired young men of diligence, intelligence, aggressiveness and sterling character," the award is made to individuals who have entered their fifth year of work at Lehigh (whether it be a second undergraduate degree or a graduate degree after a first undergraduate degree). The winners are determined by the Committee on Undergraduate Awards and Prizes on the basis of leadership, citizenship and scholarship.

Class of 1904 Award. The award is presented to an outstanding member of the junior class on the basis of character, scholarship, qualifications indicating promise of future leadership, and extracurricular activities.

C.J. Osborn Award in Metallurgy and Materials Engineering. The award is presented to a senior in the department of metallurgy and materials engineering who is deemed worthy of recognition by the faculty of the department.

Pat Pazzetti Award. The award made in honor of Vincent J. "Pat" Pazzetti, Jr., '15, is presented to a Lehigh football player of outstanding ability.

The Pennsylvania Institute of Certified Public Accountants Prize. The plaque goes to the senior in the College of Business and Economics majoring in accounting who is outstanding in academic achievement and leadership.

Phi Sigma Kappa Scholarship Cup. This cup, awarded to the fraternity having the highest scholastic average for the preceding year, becomes the permanent property of the fraternity winning it for three successive years. The original cup was provided by an alumnus of the Nu Chapter of Phi Sigma Kappa in 1923. Cups are provided by the local chapter.

Pi Tau Sigma Prize. The honorary fraternity in mechanical engineering awards a mechanical engineers' handbook to the highest-ranking sophomore in mechanical engineering.

Leonard P. Pool Memorial Award. This award is made annually to a junior or senior student exhibiting entrepreneurial talents. Mr. Pool was chairman of Air Products and Chemicals, Inc.

The Allen S. Quier Prize in Metallurgy. A prize has been provided by the daughters of the late Allen S. Quier in memory of their father, to be awarded to the senior who is adjudged by the staff of metallurgy and materials engineering to have made the most progress in that curriculum. While high scholastic standing is a requisite, the prize is awarded on the basis of progressive achievement in scholastic work, rather than an average rating.

Bosey Reiter Leadership Cup. This award is given to the student whose leadership contributes primarily to the best interests of the university. Leadership is defined chiefly as moral character and combines intellectual ability and common sense. High scholarship and athletic achievements are included as cases of leadership, but neither is necessary or sufficient alone.

Robert Ridgway Senior Prize. This prize is awarded to the senior in the College of Engineering and Applied Science with the highest cumulative average.

Col. Edward W. Rosenbaum Award. The award, in honor of Robert Rosenbaum, '17, is awarded each year to recognize the outstanding senior aerospace studies student.

Margaret B. Savic Tennis Award. The award is made to the most valuable player on the tennis team.

William H. Schempf Award. This award is made annually to the freshman who has shown outstanding ability and interest beyond the requirements of a normal freshman bandsman. It is made in honor of a former head of the music department by the Beta Sigma chapter of Theta Chi social fraternity.

The Senior Band Plaque. The plaque was established by the seniors on the executive committee of the Lehigh University Band to honor a member or members of the senior class of the band who have given outstanding performances in both marching and concert seasons for four years and who have not served in a major administrative capacity in the band.

T. Edgar Shields Band Cup. This is awarded to the student who has made the greatest musical contribution to the band.

T. Edgar Shields Glee Club Cup. This cup is awarded to the student who made the greatest musical contribution to the Glee Club.

Sigma Xi Undergraduate Research Award. A cash award and associate membership in the society is made to an undergraduate student by the chapter executive committee from departmental nominations. The basis of the award is research potential and demonstrated achievement in research.

Spillman and Farmer Architectural Award. An architectural book and a cash award are made to the student(s) creating the outstanding architectural or environmental design in the architecture classes of the department of art and architecture.

John S. Steckbeck Award. This award is presented annually to the most outstanding woman freshman athlete in good academic standing. It honors the memory of its namesake, who was director of intramurals.

Alan H. Stenning Award. A prize is awarded to a senior mechanical engineering or mechanics student for excellence in an undergraduate engineering project.

Bradley Stoughton Student Award. This award is given to an outstanding senior in the metallurgy and materials engineering department. It consists of a certificate and cash award.

Tau Beta Pi Prize. The engineering honorary fraternity awards a prize to the engineering sophomore having the highest scholastic average.

Thornburg Mathematics Prize. This prize is made possible through a bequest by the late W.P. Tunstall, '03, in honor of Charles L. Thornburg, who was pro-

fessor of mathematics. The prize, consisting of a credit to purchase books in the field of mathematics or allied disciplines at the bookstore, is awarded to the senior with the most outstanding record in advanced courses in mathematics.

Trustees' Scholarship Cup. The trustees have provided this cup, which is awarded for one year to the living group having the highest scholarship average for the preceding year. The cup becomes the permanent property of any living group winning it for three consecutive years.

Harry M. Ullmann Chemistry Prize. The prize goes to the highest-ranking seniors in chemistry and chemical engineering.

Undergraduate Merit Award(s) of the Lehigh University Alumni Association. Seniors who by exemplary character, personality, scholarship, and participation in extracurricular activities represent(s) the highest traditions of Lehigh University are honored.

University Service Award. This award is given to the senior who has been adjudged to have contributed most during his or her career at Lehigh to promote student body unity, campus cooperation for worthy objectives, and loyalty to the alma mater. It is expected that the student selected shall be of sound character and satisfactory scholarship.

John R. Wagner Award. This award goes to the junior student in mechanical engineering whose scholastic record is the highest in his or her class in the freshman and sophomore years and whose character and life purposes are deemed deserving and worthy.

Wall Street Journal Award. This is awarded to a senior finance major primarily on the basis of scholarship.

William Whigham, Jr., Memorial Prize. This is awarded to the top-ranking freshman in engineering, based on high cumulative average in the first two semesters.

Elisha P. Wilbur Prizes. A fund was established by E.P. Wilbur, trustee from 1872 until 1910, for distribution in prizes as the faculty might determine. The income from this fund provides two awards, as follows: *Wilbur Mathematics Prizes.* A first and second prize is awarded to the two highest-ranking freshman engineers in mathematics. *Wilbur Scholarship Prize.* This prize is awarded to the sophomore with the best average.

Williams Prize in Creative Writing. A prize is awarded to the author of a meritorious short story, play, or poem submitted by an undergraduate.

Williams Prize in Dramatics. A prize is awarded to an undergraduate whose interpretation of a role in production is judged most outstanding.

Williams Prizes in English. Professor Edward H. Williams, Jr., Class of 1875, established prizes for excellence in English composition and public speaking. First, second and third prizes are awarded by the faculty to students in their freshman, sophomore, and junior years.

Williams Prize in Interpretive Reporting. A prize is awarded to an undergraduate for meritorious reporting, published or unpublished, intended to interpret the meaning of events or developments that are significant in the life of the university.

Williams Senior Prizes. These prizes are awarded by the faculty on the recommendation of the committee on Williams Prizes. First, second, and third prizes are awarded in each of the five fields of economics, English, philosophy, psychology, and history and government for dissertations submitted by seniors on or before April 15. The committee on Williams Prizes publishes a list of recommended subjects for dissertations; but a senior may submit a dissertation on any other subject in the respective field if the subject has received the approval of the committee. Each senior entering the competition submits to the committee his or her choice of subject and plan of work by November 15. The awards are made by the faculty upon recommendation of the committee, but no award is made if a dissertation does not meet the standards of merit established by the committee. This standard includes such points as excellence in thought, plan, development, argument, and composition.

The Theodore B. Wood Prize. A prize is awarded under the terms of the will of Theodore Wood to the mechanical engineering student who has made the greatest scholastic improvement during the first two years of the college course.

How to Reach Bethlehem

Those who plan to visit Lehigh University can reach Bethlehem, Pa., by private car or commercial carrier. The university is located approximately ninety miles from New York City and sixty miles from Philadelphia.

A bus depot is located just two blocks from the university campus. The Allentown-Bethlehem-Easton Airport, just fifteen minutes away by cab or airport limousine, is served by a number of airlines.

Construction of the final segment of the I-78 interstate highway system is underway, and will bring the route between Lehigh's Hilltop and Murray H. Goodman campuses.

The following information may be of assistance to those planning to visit the campus.

By plane. Allentown-Bethlehem-Easton International Airport is served by several airlines.

By bus. Trans Bridge Lines offers daily service to New York City, Newark International Airport, and Atlantic City, N.J. Carl R. Bieber Tourways offers regular service to and from Philadelphia. Greyhound also provides service for Bethlehem.

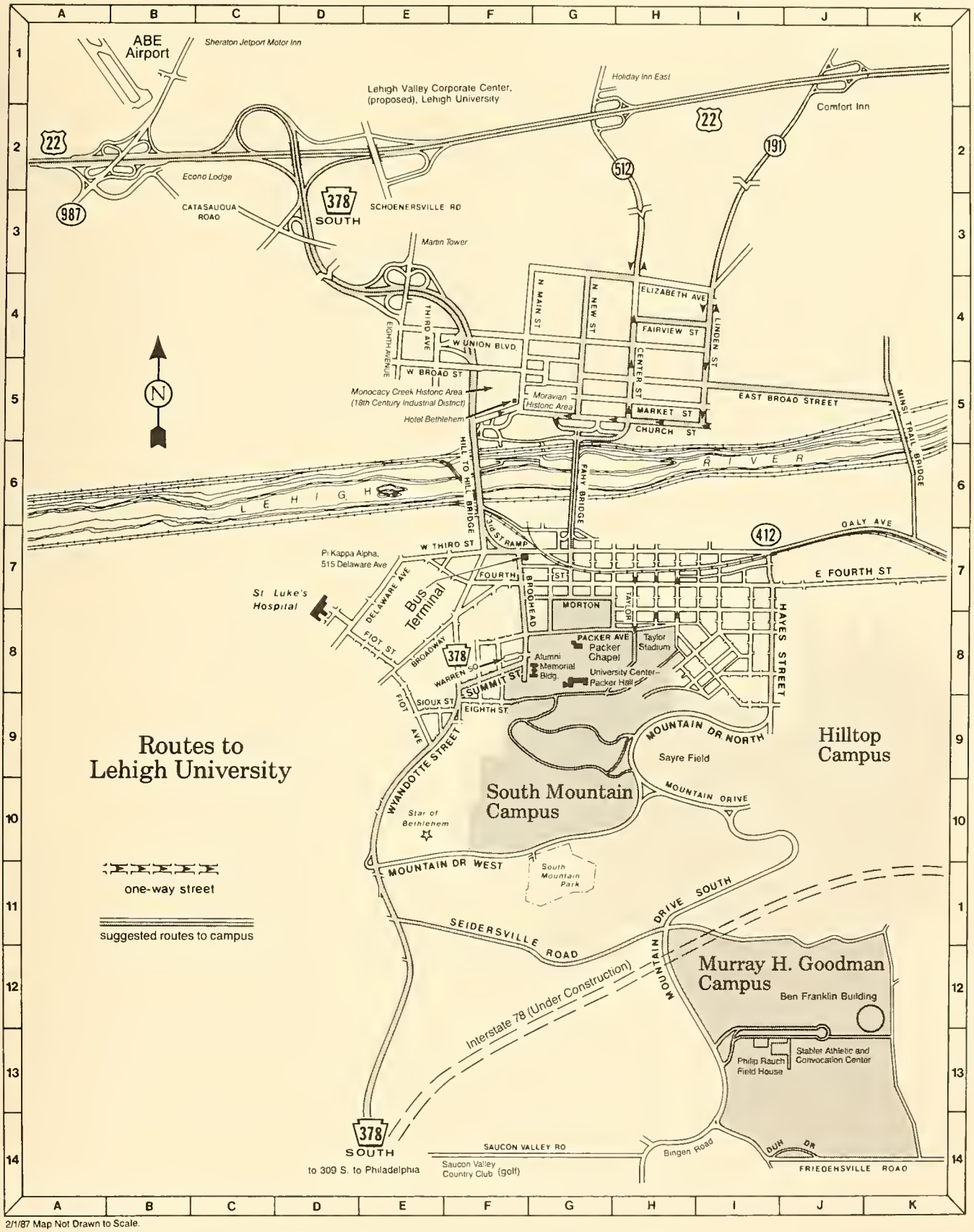
Driving from New York City area. Take Route 22 (also I-78) west and leave at the last Bethlehem exit, Route 378. Route 378 heads only south; continue for 3.6 miles and when you cross the bridge over the Lehigh River, be careful to stay in the left lane. Turn left at the traffic light for Third St. at the far end of the bridge; continue one block to the traffic light at Brodhead Ave., and turn right. (The Bethlehem bus terminal will be across the street when you turn.) Continue approximately three blocks until you see a parking lot on your right. Park in the lot and walk about half a block up the hill and across Brodhead Ave. to the Alumni Memorial Building, location of the office of admission.

Driving from western points. Take Route 22 (I-78) east, exiting at Route 378, which is the first of three Bethlehem exits. Continue south as described above.

From Philadelphia. Take Route 309 (Bethlehem Pike) north to Center Valley. Turn right onto Route 378 and go over the first mountain you see. About halfway down the far side of the mountain (after a total of 5.4 miles on Route 378), turn right onto Summit St. Continue for about two blocks, to the point where Summit St. terminates at Brodhead Ave. The university is directly ahead. Continue down Brodhead just beyond Packer Ave. and park in the lot on your left.

An alternative is to take the Northeast Extension of the Pennsylvania Turnpike north to Exit 32, then head east for 3.5 miles on Route 663. Turn left onto Route 309 in Quakertown. Continue on Routes 309 and 378 as described above.

Deliveries. Commercial carriers should make inquiries regarding deliveries with appropriate offices. Road restrictions may apply.



2/1/87 Map Not Drawn to Scale.

Lehigh University Main Campus

Many of the university offices visited by students, candidates, and parents are scattered across the main South Mountain campus. The guide below locates a few of the more frequently visited offices.

Admission—Alumni Memorial Building C-5
Bursar—Alumni Memorial Building C-5
Career Planning and Placement Services—Christmas-Saucon Hall F-4
Chaplaincy Services—Johnson Hall E-6
College of Arts and Science—Maginnes Hall D-3
College of Business and Economics—Drown Hall F-6
College of Education—524 Brodhead Ave. B-4 (moving to Hilltop Campus, 1987)
College of Engineering and Applied Science —Packard Laboratory D-4
Counseling Service—Johnson Hall E-6
Financial Aid—218 W. Packer Ave. B-4
Graduate School—Whitaker Laboratory F-3
Health Center—Johnson Hall E-6
President's Office—Alumni Memorial Building C-5
Registrar—Alumni Memorial Building C-5
Research—Whitaker Laboratory F-3 (headquarters)
Residence Operations—Rathbone Hall J-5
University Police—Packer Hall, the university center E-6

University Facilities

Alumni Memorial Building C-5
Audio-Visual Center F-4 annex
Chandler-Ullmann Hall F-4
Christmas-Saucon Hall F-4
College of Education B-4 (moving to Hilltop Campus, 1987)
Computer Store C-5
Computing Center E-3
Coppee Hall F-6
Coxe Laboratory G-6
Drown Hall F-6
Educational Technology Center A-1
E.W. Fairchild-Martindale Library and Computing Center E-3
Fritz Engineering Laboratory and Annex G-4
Grace Hall H-5, 6
Johnson Hall E-6
Lamberton Hall F-6
Linderman Library F-5
Maginnes Hall D-3
Mart Science and Engineering Library E-3
Harold S. Mohler Laboratory B-4
Seeley G. Mudd Building F-3
Neville Hall F-3
Packard Laboratory D-4
Packer Hall, the university center E-6
Packer Memorial Church E-4
Philosophy Building E-4
Physics/Physical Sciences G-4
President's House D-5
Price Hall G-6
Rathbone Hall J-5
Office of Research G-3
Sherman Fairchild Center for the Physical Sciences G-4
Sinclair Laboratory F-3
Small Business Development Center E-2
Taylor Gymnasium H-5
Taylor Stadium J-4
Town House B-5
Whitaker Laboratory F-3
Wilbur Drama Workshop G-4
Williams Hall G-5

Residential Buildings

Brodhead House C-2
Beardslee House K-5
Carothers House K-5
Centennial I houses J-6, K-5
Centennial II houses K-4, 5
Congdon House (Alpha Phi) K-5
Dravo House G-7
Drinker House G-7
Emery House (Gamma Phi Beta) K-5
German House, 210 Warren Square B-5
Gipson Residential College, Murray H. Goodman Campus D-4
Hartman Residential College, Murray H. Goodman Campus D-4
Hillel House, 214 Summit St. B-5
International House, 220 Warren Square B-5
Leavitt House (Alpha Gamma Delta) K-6
McClintic-Marshall House J-6
McConn House (Alpha Omicron Pi) J-6
More Residential College, Murray H. Goodman Campus C-4
Packer House, 217 W. Packer Ave. B-3
Palmer House K-5
Richards House H-7
Saucon Village Apartments, Murray H. Goodman Campus CD-4
Severs House, Murray H. Goodman Campus C-4
Smiley House (Kappa Alpha Theta) J-6
Stevens House K-4
Stoughton House K-4
222 Summit House K-4
Taylor Residential College E-7
Thornburg House J-6
Trembley Park apartments D-6
532-534 Brodhead Ave. B-5
Williams House K-5

Fraternity Residences

Alpha Chi Rho D-10
Alpha Epsilon Pi, 308 W. Packer Ave.
Alpha Sigma Phi D-9
Alpha Tau Omega G-9
Beta Theta Pi D-8
Chi Phi D-9
Chi Psi C-8
Delta Chi, 233 W. Packer Ave. A-4; annex 230 W. Packer Ave.
Delta Phi B-8
Delta Tau Delta C-8
Delta Upsilon C-7
Kappa Alpha B-8
Kappa Sigma A-9
Lambda Chi Alpha F-10
Phi Delta Theta E-8
Phi Gamma Delta D-9
Phi Kappa Theta A-9
Phi Sigma Kappa C-9
Pi Kappa Alpha, 545 Delaware Ave.
Pi Lambda Phi F-10
Psi Upsilon C-7
Sigma Alpha Mu C-11
Sigma Chi E-8
Sigma Nu D-7
Sigma Phi F-7
Sigma Phi Epsilon B-9
Tau Epsilon Pi, 227-229 Warren Square B-5; annex 216 Warren Square
Theta Chi C-9
Theta Delta Chi F-8
Theta Xi E-10
Zeta Psi F-9

Sorority Residences

Alpha Gamma Delta (Leavitt House) J-6
Alpha Omicron Pi (McConn House) J-6
Alpha Phi (Congdon House) K-5
Delta Gamma, 715 E. Seventh St.
Gamma Phi Beta (Emery House) K-6
Kappa Alpha Theta (Smiley House) J-6

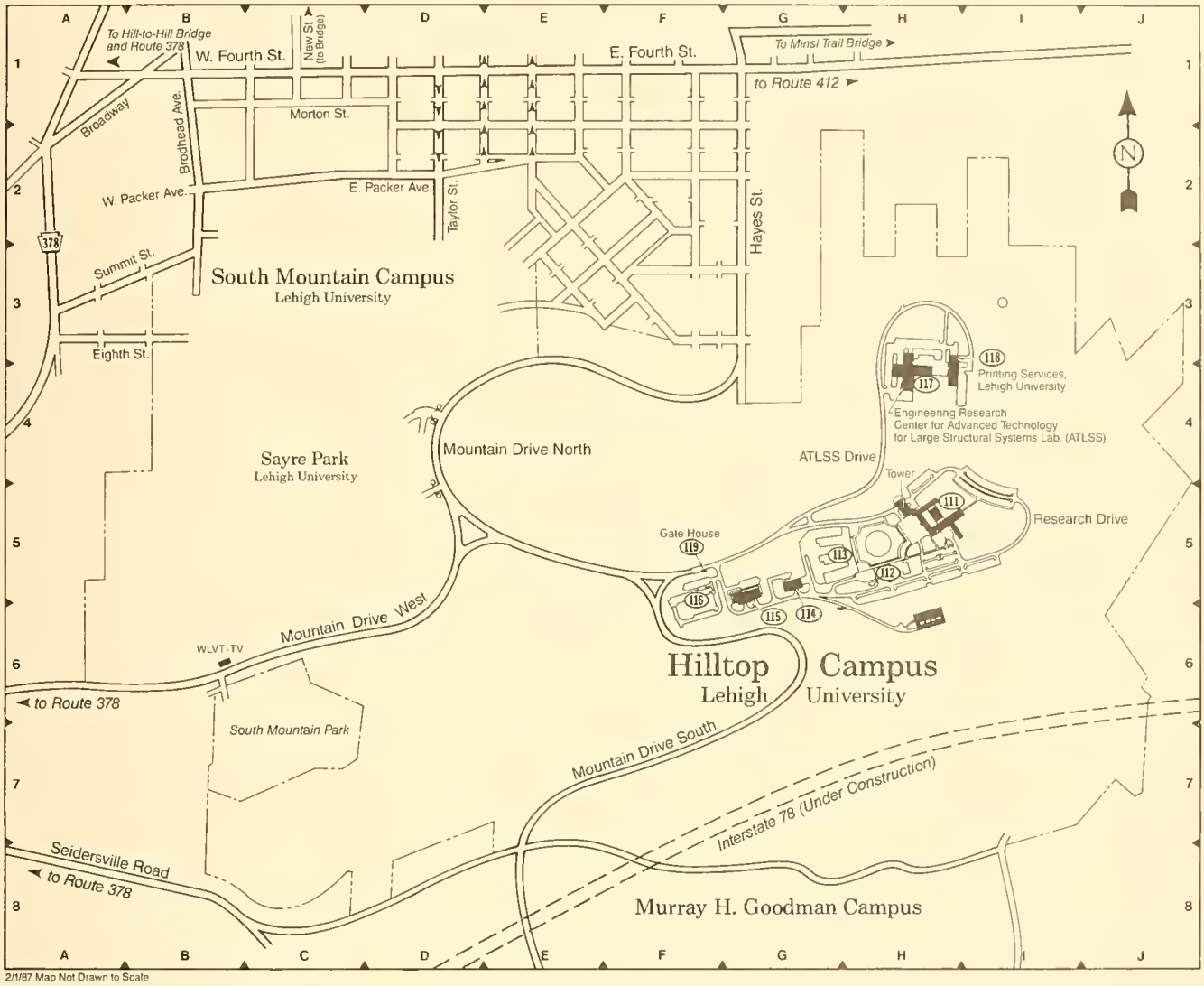
Lehigh University

2/1/87 Map Not Drawn to Scale.

Hilltop Campus

The area is called the Hilltop Campus throughout this catalog. However, the designation Mountaintop Campus has been established as the name and will be used in subsequent printing of maps and in other references.

111 Tower building
114 Central heating and refrigeration, Hilltop Campus
115 Ben Franklin Center industrial facility
117 ATLSS—Engineering Research Center for Advanced Technology for Large Structural Systems Laboratory
118 Printing services, Lehigh University
119 Gatehouse


To Hill-to-Hill Bridge and Route 378
W. Fourth St.
New St. (to Bridge)
E. Fourth St.
To Minsi Trail Bridge
to Route 412
Broadway
Brodhead Ave.
Morton St.
W. Packer Ave.
E. Packer Ave.
Taylor St.
Hayes St.
378
Summit St.
South Mountain Campus
Lehigh University
Eighth St.
Sayre Park
Lehigh University
Mountain Drive North
ATLSS Drive
Tower
Research Drive
Gate House
Printing Services, Lehigh University
Engineering Research Center for Advanced Technology for Large Structural Systems Lab. (ATLSS)
WLVT-TV
Mountain Drive West
Hilltop Campus
Lehigh University
to Route 378
South Mountain Park
Mountain Drive South
Interstate 78 (Under Construction)
Seidersville Road
to Route 378
Murray H. Goodman Campus
N
2/1/87 Map Not Drawn to Scale

Murray H. Goodman Campus

The Murray H. Goodman Campus, located in the Saucon Valley area just to the south of the main South Mountain and the Hilltop campuses, offers athletic fields and tennis courts. The headquarters of North East Tier Ben Franklin Advanced Technology Center also is on the site.

Ben Franklin Building D-2
LaSasso Squash Court C-3
Philip Rauch Field House C-3
Saucon Village Apartments CD-4
  Diamond
  Gipson Residential College
  Hartman Residential College
  More Residential College
  Severs
Stabler Athletic and Convocation Center C-3
Transportation Services E-2
Varsity House locker facility B-3

2/1/87 Map Not Drawn to Scale.

Geographical Distribution of Students

All figures are for fall, undergraduates only.

	1985	1986
Alabama		1
Alaska	1	1
Arizona		1
California	24	23
Colorado	8	8
Connecticut	325	335
Delaware	24	26
District of Columbia	6	8
Florida	47	57
Georgia	9	15
Hawaii	3	4
Illinois	20	26
Indiana	2	2
Kansas	3	2
Kentucky	1	1
Louisiana	3	3
Maine	9	7
Maryland	126	116
Massachusetts	140	157
Michigan	4	7
Minnesota	3	3
Missouri	5	7
Montana	1	1
Nebraska		1
New Hampshire	14	12
New Jersey	1340	1320
New York	769	795
North Carolina	7	9
Ohio	43	48
Oregon	2	2
Pennsylvania	1385	1315
Puerto Rico	7	12
Rhode Island	12	19
South Carolina	3	5
Tennessee	3	2
Texas	9	16
Vermont	5	7
Virginia	38	46
Virgin Islands	1	1
Washington	3	1
West Virginia	2	3
Wisconsin		1
total	4407	4426

Foreign	1985	1986
Australia		1
Austria	1	1
Bahamas	1	1
Belgium	3	2
Bermuda	2	1
Brazil	4	2
Brunei		1
Canada	1	4
China (Peoples Republic)	2	1
Colombia	5	4
Costa Rica	2	3
Cyprus	9	7
Ecuador	7	6
El Salvador		3
France	1	1
Germany	3	2
Greece	5	2
Guatemala	4	5
Honduras	2	2
Hong Kong	6	7
India	3	3
Italy	1	3
Japan	6	7
Kenya	1	2
Korea	4	5
Kuwait	2	3
Malaysia	1	8
Mexico	2	2
Morocco	1	
Netherlands	2	3
Norway	4	3
Pakistan	2	5
Panama	3	2
Peru	4	4
Philippines	8	7
Qatar		1
Singapore	1	2
Spain	1	
Switzerland	3	3
Taiwan	1	1
Thailand	2	5
Trinidad	5	4
Turkey		3
United Arab Emirates	3	4
United Kingdom	5	4
Venezuela	5	5
West Indies Federation		1
Venezuela	5	5
total	128	146
final total	4538	4572

Registration Statistics

Fall 1986

	fresh-men	sopho-mores	juniors	seniors	total
Accounting		4	77	104	185
American Studies				1	1
Applied Science		1	1	10	12
Architecture	1	9	17	19	46
Art		1	2		3
Arts-Engineering	36	15	3	1	55
Arts and Science	533	409	38	2	982
Biochemistry	1		6	7	14
Biology		5	22	30	57
Business	169	246	168	7	590
Chemical Engineering		38	29	37	104
Chemistry		1	5	4	10
Civil Engineering		39	33	30	102
Classics			1		1
Computer Engineering	1	27	26	33	87
Computer Science		11	27	39	77
Computer & Information Science			1	5	6
Economics		1	32	24	57
Electrical Engineering		112	113	126	351
Engineering	417	41	11	4	473
Engineering Mechanics		2			2
Engineering Physics		5	3	9	17
English			11	15	26
Environmental Science and Resource Management				4	4
Finance		1	69	141	211
Foreign Careers		5	17	14	36
French		1	1	2	4
Fundamental Science			2		2
General College Division					30
Geological Sciences		2	4	2	8
Geology				1	1
German				2	2
Government		2	19	22	43
History		3	17	7	27
Industrial Engineering		60	69	63	192
Interdepartmental				4	4
International Relations		5	18	20	43
Journalism			10	16	26
Journalism/Science Writing			3	3	6
Management		1	4	10	15
Marketing			24	55	79
Materials Science & Engineering		12	3	2	17
Mathematics		1	14	5	20
Mechanical Engineering		95	93	104	292
Metallurgy and Materials Engineering			13	17	30
Molecular Biology	1			4	5
Music				1	1
Natural Science			2	2	4
Philosophy		1	3	3	7
Physics				3	3
Predental		1	2		3
Premed		3	7	4	14
Psychology		2	24	22	48
Religion Studies				1	1
Social Relations		1	11	9	21
Spanish			1	2	3
Statistics		1	4	4	9
Studio Art			2	4	6
Theatre			2	1	3
Urban Studies			1	3	4

Registration

	spring 1985	summer 1985	fall 1985	spring 1986	summer 1986	fall 1986
undergraduate	4,286	606	4,465	4,381	705	4,573
graduate students	1,908	1,010	1,927	1,970	1,141	1,956
special students	6		4			
totals	6,200	1,616	6,396	6,351	1,846	6,529

Graduate Enrollment

A total of 1,237 men and 719 women took graduate studies at the university in the fall of 1986, for a total of 1,956. A breakdown by area of study and degree sought is provided below, listing both part-time and full-time students.

Applied Mathematics, 3 M.S., 3 Ph.D.; Applied Mechanics, 1 M.S., 13 Ph.D.; Biochemistry, 2 M.S.; Biology, 12 M.S., 9 Ph.D.; Business and Economics, 4 M.S., 1 D.A.; Business Administration, 293 M.B.A.; Chemical Engineering, 62 M.S., 1 M.Eng., 60 Ph.D.; Chemistry, 37 M.S., 1 D.A., 41 Ph.D.; Civil Engineering, 31 M.S., 18 Ph.D.; Computer Engineering, 1 M.S.; Computer Science, 44 M.S.; 9 Ph.D.; Computing and Information Science, 3 M.S., 2 Ph.D.; Economics, 1 M.S., 21 Ph.D.; Education, 46 M.S., 20 D.A., 15 Ph.D., 209 M.Ed., 94 D.Ed., 27 Ed.S.; Electrical Engineering, 98 M.S., 1 M.Eng., 23 Ph.D.; English, 21 D.A., 10 Ph.D.; Geology, 12 M.S., 1 D.A., 4 Ph.D.; Government, 7 D.A., 3 M.A., 3 M.P.A.; History, 8 D.A., 1 Ph.D.; Industrial Engineering, 63 M.S., 1 M.Eng., 15 Ph.D.; Management Science, 13 M.S.; Management Systems Engineering, 38 M.S.; Materials Science and Engineering, 19 M.S., 2 M.Eng., 14 Ph.D.; Mathematics, 11 M.S., 6 M.A., 21 Ph.D.; Mechanical Engineering, 59 M.S., 3 M.Eng., 32 Ph.D.; Metallurgy and Material Engineering, 20 M.S., 1 M.Eng., 14 Ph.D.; Molecular Biology, 1 M.S., 1 Ph.D.; Physics, 13 M.S., 38 Ph.D.; Physiological Chemistry, 1 M.S.; Polymer Science and Engineering, 7 M.S., 13 Ph.D.; Psychology, 5 M.S., 3 D.A., 7 Ph.D.; Public Administration, 6 M.P.A.; Social Relations, 11 D.A., 1 M.A.

In addition, 238 students enrolled in various programs had not designated the graduate degree sought.

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Academic Calendar

The university academic calendar has evolved over the years to reflect the desires of students and faculty and the needs of the university as a whole.

Generally speaking, classes are scheduled only Monday through Friday. Typically, a three-credit-hour course is offered with either three fifty-minute class sessions Monday, Wednesday, and Friday morning, or with two seventy-five minute classes on Tuesday and Thursday morning. Afternoon classes Monday through Friday are scheduled in either fifty-minute or seventy-five minute segments.

Students should note that the fall semester concludes prior to the holiday vacation in December. To make this possible, classes commence at the end of August. In the spring semester, classes begin following the semester break, and conclude in mid-May.

While every effort has been made to include correct dates in the calendar that follows, the faculty or the University Forum may exercise their right to make changes.

Spring, 1987

March 2 (Monday)—Last day for filing applications for degrees to be conferred in May
March 7 (Saturday)—Spring vacation begins (12 noon)
March 16 (Monday)—Spring vacation ends (8:10 A.M.); midsemester reports due
March 24 (Tuesday)—Last day to withdraw from courses with a W
March 26 (Thursday)—Four o'clock quizzes
March 31 (Tuesday)—Four o'clock quizzes
April 1 (Wednesday)—Four o'clock quizzes
April 2 (Thursday)—Four o'clock quizzes
April 6 (Monday)—Preregistration begins
April 10 (Friday)—Preregistration ends
April 15 (Wednesday)—Easter vacation begins (10 P.M.); Monday classes meet
April 21 (Tuesday)—Classes resume (7:45 A.M.)
April 24 (Friday)—Last day for May doctoral candidates to submit to the dean of the Graduate School approved dissertation drafts
May 1 (Friday)—Last day of classes in the spring semester
May 2-5 (Saturday to Tuesday)—Review-consultation-study period
May 6 (Wednesday)—Course examinations begin
May 15 (Friday)—Course examinations end
May 18 (Monday)—Last day for May candidates for master's degrees to submit to the dean of the Graduate School unbound copies of their theses
May 20 (Wednesday)—Last day for June doctoral candidates to complete all degree requirements
May 30 (Saturday)—University Day (commencement)

1987

MARCH

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

APRIL

S	M	T	W	T	F	S
			1	2	3	4
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26	27	28	29	30		

MAY

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24	25	26	27	28	29	30
31						

JUNE

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28	29	30				

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29	30					

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1988

JANUARY

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24	25	26	27	28	29	30
31						

FEBRUARY

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28	29					

MARCH

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20	21	22	23	24	25	26
27	28	29	30	31		

APRIL

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24	25	26	27	28	29	30

MAY

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8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

JUNE

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			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

Summer, 1987

First Session

May 18-26—Graduate registration
May 26 (Tuesday)—Undergraduate registration;
May 26-July 1 Classes in session
May 29 (Friday)—Monday classes meet
June 5 (Friday)—Thursday classes meet
July 2-3 (Thursday and Friday)—Course examinations

Second Session

June 29-July 6—Graduate registration
July 6 (Monday)—Undergraduate registration
July 6 - August 13—Classes in session
August 14-15 (Friday and Saturday)—Course examinations

Fall, 1987

August 17-21 (Monday to Friday)—Graduate registration
August 21-23 (Friday to Sunday)—Freshman orientation
August 24-25 (Monday and Tuesday)—Undergraduate registration
August 26 (Wednesday)—First day of instruction
September 1 (Tuesday)—Last day for filing application for Founder's Day degree
September 4 (Friday)—Last day for October doctoral candidates to deliver approved dissertation drafts to the dean of the Graduate School
September 7 (Monday)—Holiday (Labor Day)
September 9 (Wednesday)—Monday classes meet; last day for fall registration and adding courses
September 14 (Monday)—First faculty meeting of the academic year
September 21-23 (Monday to Wednesday)—Engineering inspection trips
September 23 (Wednesday)—Last day for October master's candidates to submit unbound thesis copies to the graduate dean
September 25 (Friday)—Last day for October doctoral candidates to complete all degree requirements
September 30 (Wednesday)—Four o'clock quizzes
October 1 (Thursday)—Four o'clock quizzes
October 2-5 (Friday to Monday)—Pacing break vacation
October 6 (Tuesday)—Four o'clock quizzes
October 7 (Wednesday)—Four o'clock quizzes
October 8 (Thursday)—Monday classes meet
October 11 (Sunday)—Founder's Day
October 19 (Monday)—Midsemester reports due
October 26 (Monday)—Preregistration begins
October 30 (Friday)—Preregistration ends
November 2 (Monday)—Last day to withdraw from a course with a W
November 3 (Tuesday)—Four o'clock quizzes
November 4 (Wednesday)—Four o'clock quizzes
November 5 (Thursday)—Four o'clock quizzes
November 10 (Tuesday)—Four o'clock quizzes
November 20 (Friday)—Last day for January doctoral candidates to deliver approved dissertation drafts to the dean of the Graduate School
November 26-29 (Thursday to Sunday)—Thanksgiving vacation
November 30 (Monday)—Classes resume; Friday classes meet
December 1 (Tuesday)—Last day to file application for conferred January degree; Thursday classes meet
December 8 (Tuesday)—Last day of classes
December 9-10 (Wednesday and Thursday)—Review-consultation-study period
December 11 (Friday)—Course examinations begin
December 16 (Wednesday)—Last day for January master's degree candidates to submit unbound thesis copies to graduate dean
December 18 (Friday)—Last day for January doctoral degree candidates to complete all degree requirements
December 20 (Sunday)—Course examinations end

Spring, 1988

January 11-15 (Monday to Friday)—Graduate registration
January 18-19 (Monday and Tuesday)—Undergraduate registration
January 20 (Wednesday)—First day of classes; last day for graduate registration
February 2 (Tuesday)—Last day for spring registration
February 19-22 (Friday to Monday)—Pacing break vacation
February 23 (Tuesday)—Four o'clock quizzes
February 24 (Wednesday)—Four o'clock quizzes; Friday classes meet
February 25 (Thursday)—Four o'clock quizzes; Monday classes meet
March 1 (Tuesday)—Last day for filing application for June graduation; four o'clock quizzes
March 21 (Monday)—Midsemester reports due
March 25 (Friday)—Last day to withdraw with a W
March 26 (Saturday)—Spring vacation begins (12 noon)
April 5 (Tuesday)—Spring vacation ends (7:45 A.M.)
April 5 (Tuesday)—Four o'clock quizzes
April 6 (Wednesday)—Four o'clock quizzes
April 7 (Thursday)—Four o'clock quizzes
April 8 (Friday)—Monday classes meet
April 11 (Monday)—Preregistration begins
April 12 (Tuesday)—Four o'clock quizzes
April 14 (Thursday)—Monday classes meet
April 15 (Friday)—Preregistration ends
May 6 (Friday)—Last day for June doctoral candidates to deliver approved dissertation drafts; last day of classes
May 9-10 (Monday and Tuesday)—Review-Consultation-Study period
May 11 (Wednesday)—Final examinations begin
May 20 (Friday)—Final examinations end
May 23 (Monday)—Last day for June master's candidates to submit unbound thesis copies to the graduate dean
May 25 (Wednesday)—Last day for June doctoral candidates to complete all degree requirements
May 31 - August 19—Summer Sessions
June 5 (Sunday)—University Day (commencement)

Summer School 1905

Top Row	Second Row		Third Row		Fourth Row	
Langstroth	DeBeaufre		Hayes	James	Cupitt	Drummond
Wallace	Vossburg	Root	March	Luederes	Watson	Nolan
Grimball	Dent	Dean	Wait	Fear	Heck	Eigenbrodt
Jefferson	Underwood	Lotz	Singer	Henry	Smart	Clingerman
				Crowther		

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